

**“FASTEN YOUR SEAT BELT, ORVILLE!”: EXPLORING
THE RELATIONSHIP BETWEEN STATE-OF-THE-ART,
TECHNOLOGICAL AND COMMERCIAL FEASIBILITY,
AND THE *RESTATEMENT*’S REASONABLE
ALTERNATIVE DESIGN REQUIREMENT**

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INTRODUCTION

Of course Wilbur never told Orville to fasten his seat belt. Not only did the first Wright Flyer have no seat belts, it did not even have seats!¹ Orville steered the Wright Flyer I from a prone position, not sitting up.² Nor was the Wright brothers’ flying machine equipped with such useful safety features as brakes, landing gear, a radio, ailerons, or even much of a tail.³ In fact, if the truth be told, the Wright brothers’ airplane was a flying deathtrap. The good news for both modern pilots and their passengers is that aircraft technology, including safety technology, has progressed enormously since 1903. Aircraft manufacturers have now incorporated many forms of technology, such as radar, global positioning navigation systems, transponders, radios, anti-lock braking systems, and fire-resistant insulation in order to make their products safer. Unfortunately, progress has not been as impressive in other areas. Consider punch presses. Notwithstanding the fact that these machines cause hundreds of injuries in the workplace each year, many punch presses continue to employ Rube Goldberg-like devices such as “pullbacks” to protect punch press operators from serious injury.⁴

Why has safety technology improved so dramatically over the last hundred years for airplanes while punch press safety technology apparently has not? One explanation for this curious result is that product manufacturers effectively control the pace of technological development, including the development of safety-related technology by deciding how much to invest in research and development.⁵ At the same time, the experience of aircraft and punch press

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1. The Wright brothers did not install seats in their aircraft until 1908. *See* T.K. DERRY & TREVOR I. WILLIAMS, *A SHORT HISTORY OF TECHNOLOGY FROM THE EARLIEST TIMES TO A.D. 1900*, at 401 fig. 199 (1961) (depicting Orville Wright lying prone on the Wright Flyer).

2. *See id.* (illustrating the Wright brothers’ 1903 flying machine).

3. *See id.*

4. *See* Buzzell v. Bliss, 358 N.W.2d 695, 697 (Minn. Ct. App. 1984) (describing safety devices).

5. *See* Beshada v. Johns-Manville Prods. Corp., 447 A.2d 539, 548 (N.J. 1982); *see also* Omri Ben-Shahar, *Should Products Liability Be Based on Hindsight?*, 14 J.L. ECON. & ORG. 325, 340 (1998); Gary T. Schwartz, *Foreword: Understanding Products Liability*, 67 CALIF. L. REV.

manufacturers suggests that some manufacturers are willing to invest more aggressively in product safety technology than others. What can be done to encourage manufacturers who lag behind to devote more effort to the improvement of product safety? One solution may be for courts to adopt tort rules that impose liability on manufacturers who fail to develop safety technology for their products. This sort of logic led the New Jersey Supreme Court in *Beshada v. Johns-Manville Products Corp.*⁶ to conclude that asbestos manufacturers would have a greater incentive to discover health risks associated with their products if knowledge of scientifically undiscoverable risks was imputed to them.⁷ Other courts have endorsed this reasoning as well.⁸

However, this reasoning assumes that manufacturers can exercise almost complete control over the pace of technological development within their industry. This assumption may in fact be true when technological development is linear in nature. Linear technological development is largely independent of technological developments in other areas. However, technological development is often interdependent.⁹ For example, developments in one technology may influence developments in another and vice versa, in what might be called a ping-pong model. Another form of development, which is analogous to the path of a pinball, occurs when technological progress flows from a number of different sources.¹⁰ In both of these situations, manufacturers will not be able to significantly affect the pace of technological development outside of their industry and no amount of tort liability will change this.

A particular technological innovation, whether safety-related or not, must also be successful in the marketplace. However, in some cases, popular acceptance takes many years and in other cases, it never happens at all. There are a variety of reasons why a particular technological innovation may not succeed commercially, including cost, lack of demand, resistance by competitors or workers in other industries, social or cultural resistance and lack of a supportive infrastructure. Although manufacturers can try to encourage public acceptance of new products and designs by advertising or engaging in other

435, 484-85 (1979); Tyrus V. Dahl, Jr., Comment, *Strict Products Liability: The Irrelevance of Foreseeability and Related Negligence Concepts*, 14 TULSA L.J. 338, 353-54 (1978).

6. *Beshada*, 447 A.2d 539.

7. *Id.* at 545-48.

8. See, e.g., *Kisor v. Johns-Manville Corp.*, 783 F.2d 1337, 1341-42 (9th Cir. 1986); *Johnson v. Raybestos-Manhattan, Inc.*, 740 P.2d 548, 549 (Haw.), *certifying questions sub nom. In re Asbestos Cases*, 829 F.2d 907 (9th Cir. 1987).

9. The idea for this comes from the BBC television series *Connections*, which aired in the United States in the late 1970s on many PBS stations. These highly informative and entertaining programs were written and hosted by science historian, James Burke. *Connections* (PBS television broadcast 1978). For background on *Connections*, see *Connections*, IMDB, <http://www.imdb.com/title/tt0078588/> (last visited Feb. 2, 2012).

10. See JAMES BURKE, THE PINBALL EFFECT: HOW RENAISSANCE WATER GARDENS MADE THE CARBURETOR POSSIBLE—AND OTHER JOURNEYS THROUGH KNOWLEDGE 3-6 (1996) [hereinafter BURKE, PINBALL EFFECT].

promotional activities, there is no assurance that these efforts will succeed.

Is there a legal concept that will encourage manufacturers to make reasonable investments in product safety without punishing them for failing to achieve the impossible? One promising solution is the “state-of-the-art” concept. Although state-of-the-art has a number of different meanings,¹¹ in design defect cases, it should normally come into play only when a plaintiff tries to prove that a product is defectively designed because an alternative design would have prevented or reduced injury.¹² In such cases, the defendant should be allowed to defeat the plaintiff’s claim by showing that his or her proposed alternative design was not within the state-of-the-art when the product was sold.

This Article begins by examining some of the case law involving the state-of-the-art concept and finds that it is principally concerned with technological feasibility. It also concludes that most cases do not treat state-of-the-art as conclusive on the design defect issue; rather, they merely consider it one of several factors that the fact finder may take into account when deciding whether a product’s design is defective or not. Part II is concerned with technological development. This part examines two basic patterns of technological development and provides a number of historical examples for each. The first is a linear pattern, exemplified by violins and clipper ships. The second pattern includes development involving the interaction of two different technologies, as exemplified by the progress of shipbuilding and naval gunnery technology during the sixteenth century, as well as more complex interactions among a number of seemingly unrelated technologies. Examples of this include printing with movable type, railroads, and motor vehicles.

Part III discusses the concept of commercial feasibility. It identifies some of the conditions that often lead to prompt commercialization of new technology. These include sudden changes in the physical environment, depletion of natural resources, military competition among nations, popular dissatisfaction with the state of existing technology, as well as changing demographic and social conditions. At the same time, the Article points out that a particular technological innovation may not succeed commercially because of high cost, lack of demand, resistance by competitors or workers in other industries, social or cultural resistance, and lack of a supportive infrastructure.

Finally, the conclusion offers suggestions on how the state-of-the-art doctrine in design defect cases could be made more rational and coherent. First, state-of-the-art is not a useful concept when applied to the defendant’s existing design. Instead, it should only be applied to evaluate a safer, alternative design proposed by the plaintiff. Second, the plaintiff must be required to prove that his or her proposed alternative design was technologically and commercially feasible at the time the product was sold. Third, the plaintiff’s proposed alternative design can be hypothetical and does not have to be actually adopted by others in the industry. Fourth, the defendant should be allowed to dispute the plaintiff’s claim by offering evidence that the proposed alternative design was not technologically

11. See DAVID G. OWEN, *PRODUCTS LIABILITY LAW* § 10.4 (2d ed. 2008).

12. *Id.* § 10.4, at 711-12.

or commercially feasible at the time the product was sold. Fifth, the defendant should be able to argue that the technology involved was interdependent and, therefore, it could not control the pace of its development. Sixth, technological and commercial feasibility should not be treated merely as factors for the jury to take into account; rather, they should be regarded as essential to the plaintiff's case. Consequently, a plaintiff who fails to prove that a proposed alternative design is technologically and commercially feasible should lose. Finally, even if the plaintiff proves that his or her proposed design is technologically and commercially feasible, the defendant should still be able to offer reasons, such as convenience, price, or consumer choice, to explain why its existing design should not make its product defective.

I. STATE-OF-THE-ART

A. Doctrinal Foundations

Courts have traditionally distinguished between three types of product defects: manufacturing defects, design defects, and inadequate warnings or instructions.¹³ These categories are also recognized by legal commentators¹⁴ and are embodied in the *Products Liability Restatement* as well.¹⁵ A manufacturing defect exists when a product fails to conform to its intended design.¹⁶ A design defect, on the other hand, occurs when a product-related risk exists which could be reduced or eliminated by an "alternative design" and the failure to do so makes "the product not reasonably safe."¹⁷ A failure-to-warn claim is based on an assertion that the manufacturer has failed to provide "reasonable instructions or warnings" which cause the product to be "not reasonably safe."¹⁸ While there is general agreement that the state-of-the-art concept is not relevant to cases involving manufacturing defects,¹⁹ it is potentially applicable to both design

13. See, e.g., *Lantis v. Astec Indus., Inc.*, 648 F.2d 1118, 1120 (7th Cir. 1981); *Piper v. Bear Med. Sys., Inc.*, 883 P.2d 407, 410-11 (Ariz. Ct. App. 1993); *Hurley v. Heart Physicians, P.C.*, 898 A.2d 777, 783 (Conn. 2006); *Cooper Tire & Rubber Co. v. Mendez*, 204 S.W.3d 797, 800 (Tex. 2006).

14. See OWEN, *supra* note 11, § 6.2; Jerry J. Phillips, *A Synopsis of the Developing Law of Products Liability*, 28 DRAKE L. REV. 317, 342 (1978); William C. Powers, Jr., *The Persistence of Fault in Products Liability*, 61 TEX. L. REV. 777, 782 (1983).

15. RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2 (1998).

16. *Id.* § 2(a).

17. *Id.* § 2(b).

18. *Id.* § 2(c).

19. See *Reed v. Tiffin Motor Homes, Inc.*, 697 F.2d 1192, 1196 (4th Cir. 1982); *Singleton v. Int'l Harvester Co.*, 685 F.2d 112, 115 (4th Cir. 1981); *Sturm, Ruger & Co. v. Day*, 594 P.2d 38, 44-45 (Alaska 1979), *modified*, 615 P.2d 621 (Alaska 1980), *overruled by Dura Corp. v. Harned*, 703 P.2d 396 (Alaska 1985); *Brady v. Melody Homes Mfr.*, 589 P.2d 896, 899 (Ariz. Ct. App. 1978). But see *Indianapolis Athletic Club, Inc. v. Alco Standard Corp.*, 709 N.E.2d 1070, 1074-75 (Ind. Ct. App. 1999) (holding that statutory state-of-the-art defense applied to manufacturing

defect and failure-to-warn cases.²⁰

1. *Failure-to-Warn*.—In many cases, particularly those involving toxic substances or prescription drugs, manufacturers have attempted to defend against failure-to-warn claims by contending that the risk in question was undiscoverable given the state of scientific knowledge at the time the product was manufactured.²¹ Some courts have rejected these attempts to invoke state-of-the-art as a defense in failure-to-warn cases, while others have been more receptive. *Beshada v. Johns-Manville Products Corp.* is illustrative of the former position,²² while *Feldman v. Lederle Laboratories* represents the latter approach.²³

In *Beshada*, the plaintiffs were injured as the result of exposure to asbestos insulation products in the workplace between 1930 and 1980.²⁴ They claimed that the defendants failed to provide warnings on their products about the health hazards of asbestos exposure.²⁵ The defendants responded that the medical profession did not become aware of the potential danger of exposure to low concentrations of asbestos until the 1960s.²⁶ However, the New Jersey Supreme Court characterized state-of-the-art as a “negligence defense” and refused to allow the defendants to raise it.²⁷ Instead, the *Beshada* court declared that under strict liability in tort, liability was based on the condition of the product rather than what the defendant knew or could have known about the product’s inherent risks.²⁸ The court supported its decision to reject the state-of-the-art defense by maintaining that it would advance various goals of products liability such as risk spreading, accident cost avoidance and facilitating the fact finding process in litigation.²⁹ In addition, the *Beshada* court emphasized that imposing liability on producers of dangerous products would encourage them to discover risks and improve product safety more rapidly.³⁰

Although a few courts agreed with the *Beshada* court’s hindsight approach and concluded that manufacturers had a duty to warn about scientifically unknowable risks,³¹ the reaction of legal commentators to the New Jersey court’s

defects).

20. *Reed*, 697 F.2d at 1196; *Brady*, 589 P.2d at 899.

21. *See, e.g.*, *Feldman v. Lederle Labs.*, 479 A.2d 374, 386 (N.J. 1984); *Beshada v. Johns-Manville Prods. Corp.*, 447 A.2d 539, 545-46 (N.J. 1982).

22. *Beshada*, 447 A.2d at 546-47.

23. *Feldman*, 479 A.2d at 386.

24. *Beshada*, 447 A.2d at 542-43.

25. *Id.* at 542.

26. *Id.*

27. *Id.* at 546.

28. *Id.*

29. *Id.* at 547-49.

30. *Id.* at 548.

31. *See Kisor v. Johns-Manville Corp.*, 783 F.2d 1337, 1341-42 (9th Cir. 1986); *Johnson v. Raybestos-Manhattan, Inc.*, 740 P.2d 548, 549 (Haw.), *certifying questions to sub nom. In re Asbestos Cases*, 829 F.2d 907 (9th Cir. 1987); *Hayes v. Ariens Co.*, 462 N.E.2d 273, 277-78 (Mass. 1984), *abrogated by Vassallo v. Baxter Healthcare Corp.*, 696 N.E.2d 909 (Mass. 1998); Elmore

decision was largely critical.³² Many of them argued that the hindsight approach imposed an impossible burden on manufacturers, that it would cause financial hardship on producers, lead to unnecessary bankruptcies, and encourage undesirable corporate behavior.³³

An opposing view is reflected by *Feldman v. Lederle Laboratories*,³⁴ ironically decided by the same New Jersey court that had decided *Beshada* two years earlier. In *Feldman*, a young girl's teeth became discolored as the result of taking Declomycin, a prescription tetracycline antibiotic manufactured by the defendant.³⁵ The plaintiff sued the drug manufacturer, claiming that it should have warned about the risk of discoloration when the drug was first marketed in 1959.³⁶ The defendant, on the other hand, insisted that the risk of tooth discoloration in humans did not become known until several years after the plaintiff was exposed to the drug.³⁷ After finding that strict liability applied to manufacturers of prescription drugs,³⁸ the court declared that the reasonableness of the defendant's conduct was a factor to consider in determining liability.³⁹ Moreover, the *Feldman* court concluded, the scientific knowledge available to the defendant was relevant to measuring the reasonableness of its conduct.⁴⁰ Although it refused to expressly overrule *Beshada*, the court restricted that case "to the circumstances giving rise to its holding," whatever those might have been.⁴¹ However, in a minor concession to *Beshada*, the New Jersey Supreme Court declared that the defendant had the burden of proving that information about the particular product risk was not available and, therefore, it had neither actual nor constructive knowledge of the need for a warning.⁴²

The *Feldman* court's foresight approach has been adopted by a majority of courts⁴³ and is also reflected in the *Products Liability Restatement*.⁴⁴ Although

v. Owens-Illinois, Inc., 673 S.W.2d 434, 438 (Mo. 1984).

32. See, e.g., James A. Henderson, Jr. & Aaron D. Twerski, *Doctrinal Collapse in Products Liability: The Empty Shell of Failure to Warn*, 65 N.Y.U. L. REV. 265, 273-80 (1990); Victor Schwartz, *The Post-Sale Duty to Warn: Two Unfortunate Forks in the Road to a Reasonable Doctrine*, 58 N.Y.U. L. REV. 892, 901-05 (1983); John W. Wade, *On the Effect in Product Liability of Knowledge Unavailable Prior to Marketing*, 58 N.Y.U. L. REV. 734, 754-56 (1983).

33. See OWEN, *supra* note 11, § 6.2; Alan Schwartz, *Products Liability, Corporate Structure, and Bankruptcy: Toxic Substances and the Remote Risk Relationship*, 14 J. LEGAL STUD. 689, 736 (1985).

34. 479 A.2d 374 (N.J. 1984).

35. *Id.* at 376-77.

36. *Id.* at 377-78.

37. *Id.* at 377.

38. *Id.* at 380-84.

39. *Id.* at 385.

40. *Id.* at 386.

41. *Id.* at 388.

42. *Id.* at 388-89.

43. See, e.g., *Lohrmann v. Pittsburgh Corning Corp.*, 782 F.2d 1156, 1164-65 (4th Cir. 1986); *Powers v. Taser Int'l, Inc.*, 174 P.3d 777, 783-84 (Ariz. Ct. App. 2008); *Gourdine v. Crews*,

this approach has much to recommend it from a fairness perspective, it is sometimes difficult to apply in practice because knowledge of a particular fact may be hard to pinpoint. For example, in *Feldman*, knowledge of the risk of tooth discoloration from ingestion of tetracycline evolved over a period of at least seven years.⁴⁵ The first study on the subject, published in 1956, revealed “that tetracycline accumulated in mineralized portions of growing bones and teeth of mice.”⁴⁶ Another study, published in 1957, reported that laboratory animals developed yellow fluorecents (not staining) in teeth and bones after receiving dosages of tetracycline.⁴⁷ Studies in 1959 and 1960 also revealed fluorecents, but not staining, in patients with cystic fibrosis following massive doses of tetracycline.⁴⁸ The link between tetracycline and permanent tooth discoloration in humans was not clearly established until 1963, when the manufacturer began to receive complaints from doctors that Declomycin (a tetracycline antibiotic) was causing tooth discoloration in patients.⁴⁹ The court let the jury determine at what point the manufacturer of Declomycin should have discovered the connection between tetracyclines and tooth discoloration.⁵⁰

It appears that the *Feldman* court’s foresight test has carried the day. Since manufacturers do not have to warn about scientifically discoverable risks, state-of-the-art evidence will be critical to the issue of whether a particular risk was scientifically discoverable at the time the product was sold.

2. *Design Defects.*—The concept of state-of-the-art also applies to product design. In the early years of products liability, however, many courts refused to allow manufacturers to introduce evidence that a safer design was not within the state-of-the-art.⁵¹ The reason for excluding state-of-the-art evidence was that it was only relevant to the reasonableness of the manufacturer’s conduct—not to the product’s condition. Thus, according to these courts, state-of-the-art evidence might be admissible in a negligence action but was irrelevant in a strict liability action where the focus was solely on the condition of the product.⁵²

955 A.2d 769, 781 n.10 (Md. 2008); *Owens-Illinois, Inc. v. Zenobia*, 601 A.2d 633, 641 (Md. 1992); *Vassallo v. Baxter Healthcare Corp.*, 696 N.E.2d 909, 922-24 (Mass. 1998); *Young v. Key Pharm., Inc.*, 922 P.2d 59, 63-65 (Wash. 1996). But see *Sternhagen v. Dow Co.*, 935 P.2d 1139, 1147 (Mont. 1997); *Green v. Smith & Nephew AHP, Inc.*, 629 N.W.2d 727, 746-47 (Wis. 2001).

44. See RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2(c) (1998).

45. See *Feldman*, 479 A.2d at 378-79 (noting evolution of discovery from 1956-1963).

46. *Id.* at 378.

47. *Id.*

48. *Id.*

49. *Id.* at 379.

50. *Id.* at 392-93.

51. See, e.g., *Dart v. Wiebe Mfg., Inc.*, 709 P.2d 876, 881-82 (Ariz. 1985); *Gelsumino v. E.W. Bliss Co.*, 295 N.E.2d 110, 113 (Ill. App. Ct. 1973); *Cryts v. Ford Motor Co.*, 571 S.W.2d 683, 686-89 (Mo. Ct. App. 1978); *Carreter v. Colson Equip. Co.*, 499 A.2d 326, 330-31 (Pa. Super. Ct. 1985).

52. See, e.g., *Rucker v. Norfolk & W. Ry. Co.*, 381 N.E.2d 715, 723-24 (Ill. App. Ct. 1978), *rev’d on other grounds*, 396 N.E.2d 534 (Ill. 1979); *Matthews v. Stewart Warner Corp.*, 314 N.E.2d

Nowadays, many courts require plaintiffs to establish that the defendant's design is defective by showing that an alternative design was potentially available to the defendant that would have prevented the plaintiff's injuries or at least have reduced the severity of those injuries. When this occurs, it becomes important to know exactly what state-of-the-art means and what kind of evidence is necessary to determine whether an alternative design is, or is not, within the state-of-the-art.

B. The Various Meanings of "State-of-the-Art" in Products Liability Law

A number of courts⁵³ and commentators⁵⁴ have pointed out that state-of-the-art has various meanings and this has led to much confusion in the law. At various times, courts have defined state-of-the-art to include the following: (1) custom or common practices within an industry;⁵⁵ (2) standards promulgated by independent standards development organizations like the American National Standards Institute (ANSI);⁵⁶ (3) standards embodied in statutes and governmental regulations;⁵⁷ and (4) technical, mechanical or scientific knowledge reasonably feasible when a product is manufactured.⁵⁸ In addition, a number of states have enacted statutes that purport to define the meaning of state-of-the-

683, 692 (Ill. App. Ct. 1974); *Gelsumino*, 295 N.E.2d at 113; *Cryts*, 571 S.W.2d at 689; *Carrecter*, 499 A.2d at 329.

53. See, e.g., *Potter v. Chi. Pneumatic Tool Co.*, 694 A.2d 1319, 1345 (Conn. 1997); *Hughes v. Massey-Ferguson, Inc.*, 522 N.W.2d 294, 298 (Iowa 1994) (Ternus, J., concurring).

54. See OWEN, *supra* note 11, § 10.4, at 706-07; Patrick R. Buckler, *State of the Art Evidence in Products Liability Suits in Maryland*, 28 U. BALT. L. REV. 117, 120 (1998); Gary C. Robb, *A Practical Approach to Use of State of the Art Evidence in Strict Products Liability Cases*, 77 NW. U. L. REV. 1, 2 (1982); Frank J. Vandall, *State-of-the-Art, Custom, and Reasonable Alternative Design*, 28 SUFFOLK U. L. REV. 1193, 1193 (1994).

55. See *Smith v. Minster Mach. Co.*, 669 F.2d 628, 633 (10th Cir. 1982); *Keogh v. W.R. Grasl, Inc.*, 816 P.2d 1343, 1349 (Alaska 1991); *Sturm, Ruger & Co. v. Day*, 594 P.2d 38, 44 (Alaska 1979), *modified*, 615 P.2d 621 (Alaska 1980), *overruled by Dura Corp. v. Harned*, 703 P.2d 396 (Alaska 1985); *Gelsumino v. E.W. Bliss Co.*, 295 N.E.2d 110, 113 (Ill. App. Ct. 1973); *Suter v. San Angelo Foundry & Mach. Co.*, 406 A.2d 140, 151 (N.J. 1979), *superseded by statutes as stated in Dewey v. R.J. Reynolds Tobacco Co.*, 577 A.2d 1239 (N.J. 1990).

56. See, e.g., *AC&S, Inc. v. Asner*, 686 A.2d 250, 254-55 (Md. Ct. App. 1996).

57. See, e.g., *Bruce v. Martin-Marietta Corp.*, 544 F.2d 442, 446-47 (10th Cir. 1976).

58. See, e.g., *Gosewisch v. Am. Honda Motor Co.*, 737 P.2d 365, 370 (Ariz. Ct. App. 1985), *opinion vacated in part by* 737 P.2d 376 (Ariz. 1987); *Indianapolis Athletic Club, Inc. v. Alco Standard Corp.*, 709 N.E.2d 1070, 1074 (Ind. Ct. App. 1999); *Falada v. Trinity Indus., Inc.*, 642 N.W.2d 247, 251 (Iowa 2002); *AC&S, Inc.*, 686 A.2d at 254; *Wiska v. St. Stanislaus Soc. Club, Inc.*, 390 N.E.2d 1133, 1138 n.8 (Mass. App. Ct. 1979); *Johnson v. Salem Corp.*, 477 A.2d 1246, 1251-52 (N.J. 1984); *Crispin v. Volkswagenwerk AG*, 591 A.2d 966, 973 (N.J. Super. Ct. App. Div. 1991); *Lancaster Silo & Block Co. v. N. Propane Gas Co.*, 427 N.Y.S.2d 1009, 1016 n.2 (App. Div. 1980); *Boatland of Hous., Inc. v. Bailey*, 609 S.W.2d 743, 748 (Tex. 1980); *Lenhardt v. Ford Motor Co.*, 683 P.2d 1097, 1099 (Wash. 1984).

art.⁵⁹

1. *Custom or Practice Within an Industry.*—“Custom of the industry” is defined as the “usual practice of the manufacturer”⁶⁰ or others within a particular industry.⁶¹ While a few courts have declared industry custom to be equivalent to state-of-the-art,⁶² most have recognized that the two concepts are different.⁶³ According to these latter courts, custom of the industry evidence describes what manufacturers within an industry have actually achieved, while state-of-the-art evidence is concerned with what is feasible for manufacturers to achieve, whether they have done so or not.⁶⁴ At the same time, some of these courts have acknowledged that industry custom may be offered as evidence of what the state-of-the-art is.⁶⁵

In a negligence case, a product is considered to be negligently designed when a manufacturer fails to exercise reasonable care when designing the product, thereby failing to make it safe for its intended uses.⁶⁶ Evidence of a custom or practice within an industry is usually admissible in a negligence action.⁶⁷ This is because one who acts like others in a trade or industry is arguably exercising reasonable care in that respect.⁶⁸ On the other hand, compliance with the custom

59. For an excellent discussion of these statutes, see DAVID G. OWEN ET AL., 1 MADDEN & OWEN ON PRODUCTS LIABILITY § 10:7, at 661-68 (3d ed. 2000).

60. *Carter v. Massey-Ferguson, Inc.*, 716 F.2d 344, 347 (5th Cir. 1983).

61. See *Gosewisch*, 737 P.2d at 370; *Falada*, 642 N.W.2d at 250; *Hughes v. Massey-Ferguson, Inc.*, 522 N.W.2d 294, 295 (Iowa 1994); *Chown v. USM Corp.*, 297 N.W.2d 218, 221 (Iowa 1980); *Lenhardt*, 683 P.2d at 1099.

62. See *Smith v. Minster Mach. Co.*, 669 F.2d 628, 633 (10th Cir. 1982); *Keogh v. W.R. Grasle, Inc.*, 816 P.2d 1343, 1349 (Alaska 1991); *Sturm, Ruger & Co. v. Day*, 594 P.2d 38, 44 (Alaska 1979), *modified*, 615 P.2d 621 (Alaska 1980), *overruled by Dura Corp. v. Harned*, 703 P.2d 396 (Alaska 1985); *Gelsumino v. E.W. Bliss Co.*, 295 N.E.2d 110, 113 (Ill. App. Ct. 1973); *Suter v. San Angelo Foundry & Mach. Co.*, 406 A.2d 140, 151 (N.J. 1979); see also *Walker v. Trico Mfg. Co.*, 487 F.2d 595, 600 (7th Cir. 1973) (characterizing expert’s testimony relating to practice of the trade as “state-of-the-art” evidence).

63. See *Carter*, 716 F.2d at 347-48; *Gosewisch*, 737 P.2d at 370; *Falada*, 642 N.W.2d at 250; *Hughes*, 522 N.W.2d at 295-96; *Chown*, 297 N.W.2d at 221-22; *Owens-Illinois, Inc. v. Zenobia*, 601 A.2d 633, 640-41 (Md. 1992); *Hancock v. Paccar, Inc.*, 283 N.W.2d 25, 35 (Neb. 1979); *Boatland of Hous., Inc.*, 609 S.W.2d at 748; *Lenhardt*, 683 P.2d at 1099; *Cantu v. John Deere Co.*, 603 P.2d 839, 840 (Wash. Ct. App. 1979); see also RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2, Reporters’ Note, at 81-84 (1998).

64. *Carter*, 716 F.2d at 347 & n.6.

65. See *Hughes*, 522 N.W.2d at 296; *Hancock*, 283 N.W.2d at 35.

66. See *Mather v. Caterpillar Tractor Corp.*, 533 P.2d 717, 719 (Ariz. Ct. App. 1975).

67. See *Holloway v. J.B. Sys., Ltd.*, 609 F.2d 1069, 1073 (3d Cir. 1979); *Collins v. Ridge Tool Co.*, 520 F.2d 591, 594 (7th Cir. 1975); *Hillrichs v. Avco Corp.*, 514 N.W.2d 94, 98 (Iowa 1994); *Spieker v. Westgo, Inc.*, 479 N.W.2d 837, 843-44 (N.D. 1992).

68. See *Rexrode v. Am. Laundry Press Co.*, 674 F.2d 826, 831-32 (10th Cir. 1982); *Garst v. Gen. Motors Corp.*, 484 P.2d 47, 61 (Kan. 1971).

of the industry is not conclusive evidence of reasonable care.⁶⁹ As Judge Learned Hand observed many years ago, industry custom is not necessarily determinative of due care because “a whole calling may have unduly lagged in the adoption of new and available devices.”⁷⁰

This principle is illustrated by *Hillrichs v. Avco Corp.*⁷¹ The plaintiff in that case was injured when his hand was caught in the rollers of the husking bed of a twenty-year-old cornpicking machine manufactured by the defendant.⁷² The plaintiff sued under negligence, breach of warranty, and strict liability, alleging that the cornpicker’s design was defective because the machine was not equipped with an emergency stop device.⁷³ The first trial resulted in a jury verdict for the manufacturer.⁷⁴ The plaintiff appealed and the Iowa Supreme Court affirmed in part, but remanded the case back for a new trial on the plaintiff’s negligence claim based on the enhanced injuries he suffered as a result of not being able to turn the machine off quickly enough.⁷⁵ At the second trial, the defendant contended that its design was consistent with the custom and practice of the farm implement industry because no cornpicker on the market was equipped with an emergency stop device.⁷⁶ However, the plaintiff responded by pointing out that at the time the cornpicker was manufactured, an emergency stop device could have been installed for less than fifty dollars and that other machines that used rollers, such as printing presses, were already equipped with such devices.⁷⁷ Declaring that compliance with industry custom was not the same as compliance with state-of-the-art, the court affirmed the lower court’s judgment for the plaintiff on his enhanced injury claim.⁷⁸

There is less agreement on the role of industry custom when the plaintiff’s case is based on strict products liability instead of negligence. A number of courts allow defendants to introduce evidence of industry custom in strict liability cases.⁷⁹ As with negligence cases, such evidence is not conclusive on

69. See *Sturm, Ruger & Co. v. Day*, 594 P.2d 38, 45 (Alaska 1979), *modified*, 615 P.2d 621 (Alaska 1980), *overruled by* *Dura Corp. v. Harned*, 703 P.2d 396 (Alaska 1985); *Caterpillar Tractor Co. v. Beck*, 593 P.2d 871, 887 (Alaska 1979); *Gelsumino v. E.W. Bliss Co.*, 295 N.E.2d 110, 113 (Ill. App. Ct. 1973); *Montgomery Ward & Co. v. Gregg*, 554 N.E.2d 1145, 1155-56 (Ind. Ct. App. 1990); *Dudley Sports Co. v. Schmitt*, 279 N.E.2d 266, 276 (Ind. App. 1972); *Garst*, 484 P.2d at 61; *Cantu v. John Deere Co.*, 603 P.2d 839, 841 (Wash. Ct. App. 1979).

70. T.J. Hooper, 60 F.2d 737, 740 (2d Cir. 1932).

71. *Hillrichs*, 514 N.W.2d 94.

72. *Id.* at 96.

73. *Id.*

74. *Id.*

75. *Id.*

76. *Id.* at 98.

77. *Id.* at 97.

78. *Id.* at 100-01.

79. See *Robinson v. Audi NSU Auto Union Aktiengesellschaft*, 739 F.2d 1481, 1486 (10th Cir. 1984); *Carter v. Massey-Ferguson, Inc.*, 716 F.2d 344, 348 (5th Cir. 1983); *Sturm, Ruger & Co. v. Day*, 594 P.2d 38, 45 (Alaska 1979), *modified*, 615 P.2d 621 (Alaska 1980), *overruled by*

the issue of defectiveness, but is only a factor for the jury to consider.⁸⁰

In *Robinson v. Audi NSU Auto Union Aktiengesellschaft*, for example, several plaintiffs who were injured in a rear-end collision brought suit against Audi, the manufacturer of their automobile.⁸¹ The crash caused the car's doors to be wedged shut and also caused the fuel tank to burst into flames.⁸² The plaintiffs alleged that the automobile was defectively designed because the fuel tank was placed where it could be easily punctured by the trunk contents when struck from behind.⁸³ The jury found in favor of the defendant and the plaintiffs appealed.⁸⁴

In their appeal, the plaintiffs argued, inter alia, that the trial court erroneously allowed the defendant to introduce evidence of customary fuel tank design to prove that their design complied with the “state-of-the-art.”⁸⁵ The defendant, on the other hand, contended that evidence of the custom and practice within the industry was relevant in a strict liability case to determine the expectations of the ordinary consumer.⁸⁶ The appeals court agreed, pointing out that since the plaintiffs had introduced evidence of fuel tank designs in other motor vehicles to show that such alternative designs were feasible, the defendant should be allowed to rely on industry custom to establish the expectations of the ordinary consumer.⁸⁷

In contrast, other courts maintain that evidence of industry custom and practices is irrelevant in a strict products liability case and distracts the jury's attention from the condition of the product to the reasonableness of the defendant's conduct.⁸⁸ For example, in *Holloway v. J.B. Systems, Ltd.*, a federal appeals court, applying Pennsylvania law, concluded that evidence of industry custom was not admissible.⁸⁹ In that case, the plaintiff was struck in the head by a bolt which broke loose from a tanker truck as it was being pressurized to

Dura Corp. v. Harned, 703 P.2d 396 (Alaska 1985); *Murphy v. Chestnut Mountain Lodge, Inc.*, 464 N.E.2d 818, 823-24 (Ill. App. Ct. 1984); *Hughes v. Massey-Ferguson, Inc.*, 522 N.W.2d 294, 296 (Iowa 1994); *Thibault v. Sears, Roebuck & Co.*, 395 A.2d 843, 850-51 (N.H. 1978).

80. See *Smith v. Minster Mach. Co.*, 669 F.2d 628, 633 (10th Cir. 1982); *Keogh v. W.R. Grasle, Inc.*, 816 P.2d 1343, 1349 (Alaska 1991); *Sturm, Ruger & Co.*, 594 P.2d at 45; *Hancock v. Paccar, Inc.*, 283 N.W.2d 25, 35 (Neb. 1979).

81. *Robinson*, 739 F.2d at 1482-83.

82. *Id.*

83. *Id.* at 1483.

84. *Id.*

85. *Id.* at 1485.

86. *Id.*

87. *Id.* at 1485-86.

88. See *Habecker v. Clark Equip. Co.*, 36 F.3d 278, 282-83 (3d Cir. 1994); *Holloway v. J.B. Sys., Ltd.*, 609 F.2d 1069, 1073 (3d Cir. 1979); *Gelsumino v. E.W. Bliss Co.*, 295 N.E.2d 110, 113 (Ill. App. Ct. 1973); *Uxa v. Marconi*, 128 S.W.3d 121, 131-32 (Mo. Ct. App. 2003); *Lewis v. Coffing Hoist Div., Duff-Norton Co., Inc.*, 528 A.2d 590, 594 (Pa. 1987); *Lenhardt v. Ford Motor Co.*, 683 P.2d 1097, 1099-1100 (Wash. 1984).

89. *Holloway*, 609 F.2d at 1073.

discharge its fuel.⁹⁰ In a strict liability case against the manufacturer of the tank, the plaintiff argued that the manufacturer should have provided a warning that the tank should not be subjected to internal pressurization.⁹¹ At trial, the plaintiff objected to testimony that the defendant, in not providing a warning with the tank, had merely conformed to the custom of the industry when the tank was manufactured six years before the accident.⁹²

On appeal, the court held that it was improper to admit testimony regarding trade custom to the effect that virtually no other tank manufacturer in 1969 provided a warning about pressurization.⁹³ Although the court ultimately concluded that the lower court had not committed reversible error, it affirmed that “negligence concepts such as ‘trade custom’ or ‘reasonable care’ have no place in suits brought under [Restatement §] 402A as that section has been interpreted by the Pennsylvania courts.”⁹⁴

2. *Industry Standards.*—Courts sometimes include industry standards within the meaning of state-of-the-art, while others distinguish the two concepts, typically concluding that industry standards are not as demanding as state-of-the-art requirements.⁹⁵ A Maryland court in *AC&S, Inc. v. Asner* defined “industry standards” as follows: “Industry standards are the practices common to a given industry. They are often set forth in some type of code, such as a building code or electrical code, or they may be adopted by the trade organization of a given industry.”⁹⁶ Industry standards fall into two basic categories: those that are formulated by the industry itself, often through trade associations; and those that are promulgated by independent standard development organizations like the American National Standards Institute (ANSI), the American Society of Mechanical Engineers (ASME), Underwriters Laboratories (UL) or the American Society for Testing and Materials (ASTM).⁹⁷ Although standards created by industry trade associations are sometimes weak or self-serving,⁹⁸ standards formulated by independent standard development organizations tend to be more

90. *Id.* at 1070-71.

91. *Id.* at 1071.

92. *Id.* at 1072.

93. *Id.* at 1073.

94. *Id.*

95. See *Mercer v. Pittway Corp.*, 616 N.W.2d 602, 622 (Iowa 2000); *AC&S, Inc. v. Asner*, 686 A.2d 250, 254-55 (Md. 1996); *Cantu v. John Deere Co.*, 603 P.2d 839, 840 (Wash. Ct. App. 1979).

96. *AC&S, Inc.*, 686 A.2d at 254-55 (quoting *Lohrmann v. Pittsburgh Corning Corp.*, 782 F.2d 1156, 1164 (4th Cir. 1986)).

97. See, e.g., *Milanowicz v. Raymond Corp.*, 148 F. Supp. 2d 525, 533 (D.N.J. 2001). Other standard setting organizations include the American Standards Association (ASA); the National Safety Council (NSC); the Society of Automotive Engineers (SAE); and the National Fire Protection Association (NFPA). See OWEN, *supra* note 11, § 2.3, at 83.

98. See, e.g., *Hall v. E.I. Du Pont de Nemours & Co.*, 345 F. Supp. 353 (E.D.N.Y. 1972) (holding blasting cap manufacturers and their trade association liable for developing inadequate safety standards with respect to warnings on blasting caps).

rigorous. These organizations require that their standards be technologically up to date, that they be developed in a transparent manner and that they reflect the consensus view of all interested parties.⁹⁹

As is the case with industry custom and practice, evidence of compliance with industry standards is usually admissible in negligence actions as proof that a manufacturer exercised reasonable care in the design of the product.¹⁰⁰ However, there is a split of authority over whether such evidence should be admissible in a strict liability case. A large number of courts allow evidence of industry standards, particularly those that have been promulgated by independent standard development organizations, to be admitted in order to establish that a product is not defective.¹⁰¹

Some courts exclude evidence of industry standards in strict liability cases because they believe that such evidence unduly focuses attention on the conduct of the manufacturer instead of the condition of the product.¹⁰² The Pennsylvania Supreme Court’s decision in *Lewis v. Coffing Hoist Division, Duff-Norton Co.*¹⁰³ exemplifies this approach. The plaintiff in that case was injured while operating an overhead electric chain-hoist to lift into position a carriage assembly component of a machine being manufactured by his employer.¹⁰⁴ The hoist could be stopped and started by means of a “control pendant,” which included a control box leading to a hoist motor overhead.¹⁰⁵ While attempting to fix a stuck chain, the plaintiff “stumbled and fell, causing his thumb to strike the ‘down’ button on the control box.”¹⁰⁶ This, in turn, caused the carriage assembly to swing forward and hit the plaintiff in the legs.¹⁰⁷ The plaintiff brought a strict liability action against the manufacturer of the hoist, claiming that the control box was

99. See Robert H. Heidt, *Damned for Their Judgment: The Tort Liability of Standards Development Organizations*, 45 WAKE FOREST L. REV. 1227, 1263-64 (2010).

100. See *AC&S, Inc.*, 686 A.2d at 255; *Back v. Wickes Corp.*, 378 N.E.2d 964, 970 (Mass. 1978).

101. See *Sappington v. Skyjack, Inc.*, 512 F.3d 440, 454 (8th Cir. 2008); *Murphy v. L & J Press Corp.*, 558 F.2d 407, 411 (8th Cir. 1977); *Stanczyk v. Black & Decker, Inc.*, 836 F. Supp. 565, 567 (N.D. Ill. 1993); *Clement v. Rousselle Corp.*, 372 So. 2d 1156, 1160 (Fla. Dist. Ct. App. 1979); *Dugan v. Sears, Roebuck & Co.*, 447 N.E.2d 1055, 1057 (Ill. App. Ct. 1983); *AC&S, Inc.*, 686 A.2d at 256; *Back*, 378 N.E.2d at 970; *Fabian v. Minster Mach. Co.*, 609 A.2d 487, 491 (N.J. Super. Ct. App. Div. 1992); *Vermett v. Fred Christen & Sons Co.*, 741 N.E.2d 954, 971 (Ohio Ct. App. 2000); *Hansen v. Abrasive Eng’g & Mfg., Inc.*, 831 P.2d 693, 697 n.5 (Or. Ct. App. 1992), *aff’d in part and rev’d in part*, 856 P.2d 625 (Or. 1993).

102. See *Habecker v. Clark Equip. Co.*, 36 F.3d 278, 286-87 (3d Cir. 1994); *Rexrode v. Am. Laundry Press Co.*, 674 F.2d 826, 831-32 (10th Cir. 1982); *Matthews v. Stewart Warner Corp.*, 314 N.E.2d 683, 691-92 (Ill. App. Ct. 1974); *Johnson v. Hannibal Mower Corp.*, 679 S.W.2d 884, 885 (Mo. Ct. App. 1984).

103. 528 A.2d 590 (Pa. 1987).

104. *Id.* at 590-91.

105. *Id.* at 591.

106. *Id.*

107. *Id.*

defectively designed because it did not have a guard or other protective feature to prevent the hoist from being accidentally activated.¹⁰⁸

The trial court granted the plaintiff's in limine motion to exclude an ASME publication which set forth standards for electric hoists and other industrial lifting equipment.¹⁰⁹ The court also ruled that the defendant could not present evidence that at least ninety percent of the control boxes made in the United States did not have guards over their activating buttons.¹¹⁰ The jury rendered a verdict in the plaintiff's favor and the defendant appealed, claiming that it was error for the lower court to exclude evidence of industry standards.¹¹¹

The Pennsylvania court declared that in order to determine the admissibility of evidence, it must first consider the relevance of the evidence to the issue in question.¹¹² Finding that industry standards were only relevant to the reasonableness of the defendant's conduct, and not to the condition of the product, the court stated that the introduction of this sort of evidence would have improperly brought concepts of negligence law into the case.¹¹³ Furthermore, the court concluded that "such evidence would have created a strong likelihood of diverting the jury's attention from the appellant's control box to the reasonableness of the appellant's conduct in choosing its design."¹¹⁴ Accordingly, the court affirmed the lower court's judgment for the plaintiff.¹¹⁵

3. *Government Regulatory Standards.*—Government standards may also serve as a measure of state-of-the-art. Government standards have traditionally been admissible in negligence cases as evidence of reasonable care although the approach is asymmetrical.¹¹⁶ In the majority of states, failure to comply with applicable regulatory standards constitutes negligence per se, that is, the defendant's conduct is deemed to be negligent as a matter of law.¹¹⁷ On the other hand, compliance with applicable regulatory standards is considered to be merely evidence of reasonable care and not conclusive.¹¹⁸ The reason for this anomaly is that many courts believe that government regulations often do not establish optimal standards of care. For example, standards may be obsolete¹¹⁹ or

108. *Id.*

109. *Id.*

110. *Id.*

111. *Id.* at 592.

112. *Id.*

113. *Id.* at 594.

114. *Id.*

115. *Id.*

116. See Richard C. Ausness et al., *Providing a Safe Harbor for Those Who Play by the Rules: The Case for a Strong Regulatory Compliance Defense*, 2008 UTAH L. REV. 115, 117.

117. See *Elsworth v. Beech Aircraft Corp.*, 691 P.2d 630, 634 (Cal. 1984).

118. See *Raymond v. Riegel Textile Corp.*, 484 F.2d 1025, 1028 (1st Cir. 1973); *Burke v. Dow Chem. Co.*, 797 F. Supp. 1128, 1142 (E.D.N.Y. 1992); *Blasing v. P.R.L. Hardenbergh Co.*, 226 N.W.2d 110, 115 (Minn. 1975); *Feiner v. Calvin Klein, Ltd.*, 549 N.Y.S.2d 692, 693 (App. Div. 1990); *Sherman v. M. Lowenstein & Sons, Inc.*, 282 N.Y.S.2d 142, 143-44 (App. Div. 1967).

119. See Mark DeSimone, Comment, *The State of the Art Defense in Products Liability*:

substantively inadequate¹²⁰ and, therefore, not reflective of an appropriate standard of due care.

Although there are exceptions,¹²¹ most courts acknowledge that government standards involving products are relevant to the issue of defectiveness.¹²² However, because they regard regulatory standards as no more than minimums, violations are treated differently than compliance. In some cases, a product that fails to comply with government standards is regarded as defective per se.¹²³ On the other hand, while manufacturers may introduce evidence that their products complied with government standards, this evidence is seldom conclusive.¹²⁴

*Bruce v. Martin-Marietta Corp.*¹²⁵ provides a good illustration of these principles. The case arose out of a tragic airplane crash in 1970, in which many members of the Wichita State University football team and some of its supporters were killed.¹²⁶ The chartered plane crashed into a mountain in Colorado while traveling to a football game in Logan, Utah.¹²⁷ During the crash, seats in the aircraft broke loose from their floor attachments and blocked the exit.¹²⁸ When the aircraft caught fire, many of the passengers were unable to escape because of the blocked exit.¹²⁹ As a result, thirty-two of the forty passengers and crew were killed.¹³⁰

Injured passengers and personal representatives of some of those killed in the accident brought suit against Martin-Marietta, the manufacturer of the airplane.¹³¹ Their negligence and strict liability claims alleged that the airplane was not crashworthy because the seat attachments were inadequate and the airplane

“Unreasonably Dangerous” to the Injured Consumer, 18 DUQ. L. REV. 915, 923 (1980).

120. See Teresa Moran Schwartz, *The Role of Federal Safety Regulations in Products Liability Actions*, 41 VAND. L. REV. 1121, 1147, 1151 (1988).

121. See *Sheehan v. Cincinnati Shaper Co.*, 555 A.2d 1352, 1354-55 (Pa. Super. Ct. 1989) (providing the admission of OSHA regulations).

122. See *Bruce v. Martin-Marietta Corp.*, 544 F.2d 442, 447 (10th Cir. 1976); *Clement v. Rousselle Corp.*, 372 So. 2d 1156, 1160 (Fla. Dist. Ct. App. 1979); *Moehle v. Chrysler Motors Corp.*, 443 N.E.2d 575, 577-78 (Ill. 1982); *Turney v. Ford Motor Co.*, 418 N.E.2d 1079, 1084-85 (Ill. App. Ct. 1981); *Hughes v. Massey-Ferguson, Inc.*, 522 N.W.2d 294, 296 (Iowa 1994); *Wilson v. Piper Aircraft Corp.*, 577 P.2d 1322, 1324-25 (Or. 1978).

123. See RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 4(a) (1998); OWEN, *supra* note 11, § 6.4, at 396-98; see also *Stanton v. Astra Pharm. Prods., Inc.*, 718 F.2d 553, 569-71 (3d Cir. 1983); *Lukaszewicz v. Ortho Pharm. Corp.*, 510 F. Supp. 961, 965 (E.D. Wis.), *opinion amended by* 532 F. Supp. 211 (E.D. Wis. 1981).

124. See *Bruce*, 544 F.2d at 446; *Moehle*, 443 N.E.2d at 578; *Brooks v. Beech Aircraft Corp.*, 902 P.2d 54, 63 (N.M. 1995).

125. *Bruce*, 544 F.2d 442.

126. *Id.* at 444.

127. *Id.*

128. *Id.*

129. *Id.*

130. *Id.*

131. *Id.*

lacked proper fire protection features.¹³² To support their design defect claim with respect to the passenger seats, the plaintiffs offered evidence that at the time of the crash there were seats in use that would have withstood the crash.¹³³ In response, the defendant alleged that when the aircraft was manufactured in 1952, it met or exceeded “all applicable design requirements, safety requirements and other criteria prescribed by the Civil Aeronautics Administration and was manufactured and certificated in accordance with specified CAA regulations.”¹³⁴

The plaintiff argued that state-of-the-art evidence was not relevant in a strict liability case.¹³⁵ Accordingly, evidence that the aircraft complied with CAA requirements in 1952 had no bearing on whether it was defective in 1970.¹³⁶ In the plaintiffs’ view, “a showing of a design defective in 1970 establishes that the plane was defective in 1952, the time of the original sale, absent a subsequent alteration of the plane.”¹³⁷ However, the court rejected this argument, declaring that compliance with CAA regulations in 1952 was evidence that the aircraft design complied with the state-of-the-art at that time.¹³⁸ Furthermore, the court concluded that an ordinary consumer would not expect an airplane manufactured in 1952 to necessarily have the safety features of one that was made in 1970.¹³⁹ Therefore, the appellate court affirmed the lower court’s summary judgment for the defendant.¹⁴⁰

4. *Technological Feasibility.*—Many courts agree that technological feasibility is the principal focus of the state-of-the-art concept as it applies to product design.¹⁴¹ Some state statutes also define state-of-the-art in terms of available technology at the time of manufacture.¹⁴² Technological feasibility

132. *Id.*

133. *Id.* at 446.

134. *Id.* (internal quotation marks omitted).

135. *Id.* at 447.

136. *Id.*

137. *Id.*

138. *Id.* at 446-47.

139. *Id.* at 447.

140. *Id.* at 449.

141. See, e.g., *Gosewisch v. Am. Honda Motor Co.*, 737 P.2d 365, 370 (Ariz. Ct. App. 1985), *opinion vacated in part by* 737 P.2d 376 (Ariz. 1987); *Indianapolis Athletic Club, Inc. v. Alco Standard Corp.*, 709 N.E.2d 1070, 1074 (Ind. Ct. App. 1999); *Falada v. Trinity Indus., Inc.*, 642 N.W.2d 247, 251 (Iowa 2002); *AC&S, Inc. v. Asner*, 686 A.2d 250, 254 (Md. 1996); *Wiska v. St. Stanislaus Soc. Club, Inc.*, 390 N.E.2d 1133, 1138 n.8 (Mass. App. Ct. 1979); *Johnson v. Salem Corp.*, 477 A.2d 1246, 1251-52 (N.J. 1984); *Crispin v. Volkswagenwerk AG*, 591 A.2d 966, 973 (N.J. Super. Ct. App. Div. 1991); *O’Brien v. Muskin Corp.*, 463 A.2d 298, 305 (N.J. 1983), *superseded by statute as stated in* *Dewey v. R.J. Reynolds Tobacco Co.*, 577 A.2d 1239 (N.J. 1990); *Lancaster Silo & Block Co. v. N. Propane Gas Co.*, 427 N.Y.S.2d 1009, 1016 n.2 (App. Div. 1980); *Boatland of Hous., Inc. v. Bailey*, 609 S.W.2d 743, 748 (Tex. 1980); *Lenhardt v. Ford Motor Co.*, 683 P.2d 1097, 1099 (Wash. 1984).

142. See, e.g., ARIZ. REV. STAT. ANN. § 12-681(10) (2012); NEB. REV. STAT. § 25-21,182 (2011).

would seem to involve more than a mere knowledge or understanding of basic scientific principles, although such knowledge or understanding is an essential first step. For example, as Heron of Alexandria’s “Sphere of Aeolus” illustrates, the ancient Greeks understood that steam could be used as a power source to operate machinery.¹⁴³ However, they were unable to put this knowledge to practical use because they did not have the technology to construct even the simplest steam engine.¹⁴⁴ Almost two thousand years elapsed before steam engines made an appearance.¹⁴⁵

Technological feasibility also requires more than an ability to conceptualize in general terms how a particular device may be designed or constructed. For example, Leonardo da Vinci produced a number of clever drawings of helicopters and flying machines in the late fifteenth century.¹⁴⁶ However, without an internal combustion engine or some other lightweight power source, none of Leonardo’s flying machines would have gotten off the ground had he tried to construct one.¹⁴⁷ In other words, manned flight in heavier-than-air machines was not technologically feasible in Leonardo’s time and would not become so for another four hundred years.

Even the construction of working models may not be enough to constitute technological feasibility because scaling up can present serious challenges. Anyone who has watched the popular television series *Mythbusters*¹⁴⁸ has no doubt observed that full-scale devices do not always behave like smaller-scale prototypes. For this reason, at least one court has refused to recognize a small-scale model of a proposed safety device as evidence that a full-scale version is technologically feasible. In *Maxted v. Pacific Car & Foundry Co.*¹⁴⁹ the plaintiff lost control of a tractor trailer rig loaded with logs, causing it to jack-knife and overturn.¹⁵⁰ The plaintiff claimed that the vehicle was negligently designed because the manufacturer failed to equip it with a device that would have

143. See DERRY & WILLIAMS, *supra* note 1, at 313 (noting that Heron used a jet of steam to rotate a wheel).

144. See *generally id.* at 312-20 (describing the beginnings of the steam engine).

145. See *id.* at 321.

146. See *id.* at 396.

147. See *id.* (“Leonardo da Vinci’s inquiries and speculations about the problems of flight represent only a renaissance intensification of an interest . . .”).

148. See *generally Mythbusters*, GOOGLE, <http://www.google.com> (query “Mythbusters”) (providing a variety of background information on the series). For example, in a recent episode, the Mythbusters, Jamie Hyneman and Adam Savage, scaled up a model of a Newton’s Cradle device in which five metal balls are suspended in a row from a frame. See *Mythbusters: Newton’s Crane Cradle* (Discovery Channel television broadcast Oct. 5, 2011), available at <http://dsc.discovery.com/videos/mythbusters-newtons-crane-cradle/>. The scale model transferred energy from the first ball to the last with ninety-eight percent efficiency. *Id.* However, this efficiency dropped to less than forty percent when the Mythbusters built a twenty foot version of the device with five one-ton balls. *Id.*

149. 527 P.2d 832 (Wyo. 1974).

150. *Id.* at 833.

jettisoned the trailer during an emergency.¹⁵¹ At trial, the plaintiff's expert witnesses acknowledged that no manufacturer within the trucking industry had ever employed such a breakaway device.¹⁵² Therefore, in order to bolster his testimony, one of the plaintiff's experts submitted a drawing of a proposed breakaway device, along with a small-scale model to show how the device would work.¹⁵³ However, the trial court rejected this proffer of evidence and granted summary judgment in favor of the manufacturer on the negligent design count.¹⁵⁴ This was affirmed on appeal, where the court declared that "[t]here was no safer design available at the time this unit was manufactured and there is absolutely no evidence of feasibility or any testing [of an alternative design]."¹⁵⁵

Of course, a device may be technologically feasible for one use, but not for another. For example, the steam engines of the early eighteenth century were adequate to pump water out of coal mines, but they were too large, heavy and inefficient to be used for transportation purposes. It was not until almost a hundred years later, and after many improvements in steam engine technology that steamships appeared, and another twenty years passed before steam engines that were suitable to transport of passengers and freight on land were developed.¹⁵⁶

Most courts allow both plaintiffs and defendants to raise the issue of technological feasibility in design defect cases, particularly when the risk-utility test is used.¹⁵⁷ The New Jersey Supreme Court addressed the relationship between technological feasibility and risk-utility analysis in *O'Brien v. Muskin Corp.*¹⁵⁸ Mr. O'Brien was injured when he dove into an above-ground swimming pool manufactured by the defendant.¹⁵⁹ The plaintiff alleged that the bottom of the pool was lined with slippery vinyl material which caused his outstretched hands to slide apart instead of breaking the force of the dive.¹⁶⁰ As a result, he

151. *Id.*

152. *Id.* at 834.

153. *Id.*

154. *Id.* at 835-36.

155. *Id.* at 836.

156. See DERRY & WILLIAMS, *supra* note 1, at 331-37.

157. See, e.g., *Caterpillar Tractor Co. v. Beck*, 593 P.2d 871, 887 (Alaska 1979), *superseded by statute as stated in Smith v. Ingersoll-Rand Co.*, 14 P.3d 990 (Alaska 2000); *Gosewisch v. Am. Honda Motor Co.*, 737 P.2d 365, 370 (Ariz. Ct. App. 1985), *opinion vacated in part by* 737 P.2d 376 (Ariz. 1987); *Hughes v. Massey-Ferguson, Inc.*, 522 N.W.2d 294, 296-98 (Iowa 1994); *Wiska v. St. Stanislaus Soc. Club, Inc.*, 390 N.E.2d 1133, 1138 (Mass. Ct. App. 1979); *Lancaster Silo & Block Co. v. N. Propane Gas Co.*, 427 N.Y.S.2d 1009, 1016 (App. Div. 1980); *Bolm v. Triumph Corp.*, 422 N.Y.S.2d 969, 974 (App. Div. 1979); *Boatland of Hous., Inc. v. Bailey*, 609 S.W.2d 743, 749 (Tex. 1980); *Cantu v. John Deere Co.*, 603 P.2d 839, 841 (Wash. Ct. App. 1979).

158. 463 A.2d 298 (N.J. 1983), *superseded by statute as stated in Dewey v. R.J. Reynolds Tobacco Co.*, 577 A.2d 1239 (N.J. 1990).

159. *Id.* at 301.

160. *Id.* at 302.

struck his head of the bottom of the pool and suffered severe injuries.¹⁶¹ The plaintiff brought suit against the manufacturer, contending that vinyl should not have been used to line the pool bottom.¹⁶² The trial court removed the design defect issue from the jury’s consideration and the jury rendered a verdict for the defendant.¹⁶³ An intermediate appellate court reversed and the defendant appealed to the New Jersey Supreme Court.¹⁶⁴

The *O’Brien* court affirmed that risk-utility analysis was appropriate “when the product may function satisfactorily under one set of circumstances, yet because of its design present undue risk of injury to the user in another situation.”¹⁶⁵ After enumerating some of the factors that were relevant to a risk-utility analysis, the court acknowledged that “[b]y implication, risk-utility analysis includes other factors such as the ‘state-of-the-art’ at the time of the manufacture of the product.”¹⁶⁶ The court then defined state-of-the-art as “the existing level of technological expertise and scientific knowledge relevant to a particular industry at the time a product is designed.”¹⁶⁷

The court observed that state-of-the-art was relevant to both sides of the risk-utility equation.¹⁶⁸ According to the court, the risk side of the equation focuses on product-related risks that the manufacturer knew or should have known about, as well as the adequacy of any warnings that may have been provided.¹⁶⁹ On the other hand, the utility side is concerned with the necessity of the product and the feasibility of alternative designs.¹⁷⁰ At the same time, the court declared that a product could comply with the state-of-the-art but still be considered defective if its overall risks outweighed its utility.¹⁷¹

Applying this analysis to the facts of the case, the court held that even though there was no evidence that it was technologically feasible to use some other material to line the bottom of the pool, it was still possible for a jury to conclude that the swimming pool was defective if it determined that the risk of injury outweighed its utility.¹⁷² Consequently, the *O’Brien* court affirmed the intermediate appellate court’s judgment and remanded the case back for a new trial on the design defect claim.¹⁷³

One of the more controversial aspects of the *O’Brien* decision was that it

161. *Id.*

162. *Id.* at 302-03.

163. *Id.* at 301-02.

164. *Id.*

165. *Id.* at 304.

166. *Id.* at 304-05 (citing *Cepeda v. Cumberland Eng’g Co.*, 386 A.2d 816 (N.J. 1978), *overruled by Suter v. San Angelo Foundry & Mach. Co.*, 406 A.2d 140 (N.J. 1978)).

167. *Id.* at 305 (citing *Robb*, *supra* note 54, at 1, 4-5 & n.15).

168. *Id.*

169. *Id.*

170. *Id.*

171. *Id.*

172. *Id.* at 305-06.

173. *Id.* at 308.

authorized the jury to hold the manufacturer liable if it concluded that the risks of the pool as designed outweighed its overall utility, even if there was no safer material available to line the bottom of the pool.¹⁷⁴ This approach has largely been rejected.¹⁷⁵ Instead, the majority of courts expect the plaintiff to propose a safer alternative design with risks and utility which can then be compared with those of the original design.¹⁷⁶ In such cases, defendants may claim that a proposed alternative design is not technologically feasible. *Caterpillar Tractor Co. v. Beck*¹⁷⁷ provides a good illustration of this. The decedent in *Beck* was killed in 1973 when his Caterpillar 944 front-end loader rolled over an embankment and crushed him.¹⁷⁸ The decedent's widow contended that her husband would not have been killed if the loader had been equipped with a roll-over protective shield (ROPS).¹⁷⁹ The parties disagreed about whether it would have been feasible for Caterpillar to have installed a ROPS when the front loader was manufactured in 1964.¹⁸⁰ The plaintiff's expert testified that auxiliary manufacturers began selling ROPS as early as 1961, thereby implying that these protective devices were technologically feasible at the time the front-end loader was manufactured.¹⁸¹

The defendant, however, argued that these after-market ROPS did not have sufficient structural integrity to protect operators against rollovers.¹⁸² According to the defendant, it began testing ROPS for its own vehicles in 1966 and first installed them on front loaders in 1969.¹⁸³ On appeal from a judgment for the plaintiff, the Alaska Supreme Court declared that the jury should consider a number of factors in its risk-utility analysis, including "the mechanical feasibility of a safer alternative design, the financial cost of an improved design, and the adverse consequences to the product and to the consumer that would result from an alternative design."¹⁸⁴

The feasibility of the plaintiff's alternative design was also an issue in

174. See *id.* at 305-06; see also James A. Henderson, Jr. & Aaron D. Twerski, *Closing the American Products Liability Frontier: The Rejection of Liability Without Defect*, 66 N.Y.U. L. REV. 1263, 1316 (1991) [hereinafter Henderson & Twerski, *Closing the Frontier*].

175. See, e.g., *Jones v. Amazing Prods., Inc.*, 231 F. Supp. 2d 1228, 1248-51 (N.D. Ga. 2002); *Parish v. Jumpking, Inc.*, 719 N.W.2d 540, 543-45 (Iowa 2006). Indeed, the *O'Brien* case itself was promptly superseded by statute. See N.J. REV. STAT. § 2A:58C-3(3) (2012); Henderson & Twerski, *Closing the Frontier*, *supra* note 174, at 1315 & n.195.

176. See Aaron D. Twerski & James A. Henderson, Jr., *Manufacturers' Liability for Defective Product Designs: The Triumph of Risk-Utility*, 74 BROOK. L. REV. 1061, 1079-93 (2009).

177. 593 P.2d 871 (Alaska 1979), *superseded by statute as stated in* *Smith v. Ingersoll-Rand Co.*, 14 P.3d 990 (Alaska 2000).

178. *Id.* at 874-75.

179. *Id.* at 875.

180. *Id.*

181. *Id.*

182. *Id.* at 876.

183. *Id.*

184. *Id.* at 886 (quoting *Barker v. Lull Eng'g Co.*, 573 P.2d 443, 455 (Cal. 1978)).

*Murphy v. Chestnut Mountain Lodge, Inc.*¹⁸⁵ The plaintiff, who was injured in a skiing accident, argued that the skis provided by the lodge were defective because they did not have an anti-friction device allowing the bindings to release when the skier’s legs were twisted during a fall.¹⁸⁶ The plaintiff’s expert testified that anti-friction devices were feasible at the time of the accident.¹⁸⁷ However, the defendant’s expert claimed that he had tested several of the anti-friction devices in development at the time and found that they were either not feasible or not effective.¹⁸⁸ Upholding a lower court judgment for the defendant, the Illinois Appellate Court held that testimony regarding the feasibility or infeasibility of the plaintiff’s proposed safer design was admissible.¹⁸⁹

5. *Commercial Feasibility.*—Most definitions of state-of-the-art focus solely on the technological aspects of feasibility and ignore the commercial aspects of technological development.¹⁹⁰ However, new technologies should not be judged solely on whether or not they work, but also whether they find acceptance in the marketplace. *Boatland of Houston, Inc. v. Bailey*¹⁹¹ is one of the few cases to take commercial feasibility into account when discussing state-of-the-art.¹⁹² In *Boatland*, the decedent was killed while operating a sixteen-foot bass boat manufactured the defendant.¹⁹³ The plaintiff was thrown from the boat when it “struck a partially submerged tree stump.”¹⁹⁴ The boat circled back and hit the decedent, killing him.¹⁹⁵ The decedent’s wife and children sued Boatland, claiming that the boat was defectively designed because it was not equipped with a “kill switch,” which would have automatically shut off the engine when Bailey was thrown into the water.¹⁹⁶ A jury verdict for the defendant was reversed by an intermediate appellate court and the plaintiffs appealed to the Texas Supreme Court.¹⁹⁷

The Texas Supreme Court declared that when the plaintiff claimed that a product was defective because it did not have a particular safety feature, the focus should be on whether the manufacturer had the ability “to provide the feature without greatly increasing the product’s cost or impairing usefulness.”¹⁹⁸

185. 464 N.E.2d 818 (Ill. App. Ct. 1984).

186. *Id.* at 820-21.

187. *Id.*

188. *Id.* at 821.

189. *Id.* at 823-24.

190. See discussion *supra* Part I.B.4.

191. 609 S.W.2d 743 (Tex. 1980).

192. See *Flock v. Scripto-Tokai Corp.*, 319 F.3d 231, 239 (5th Cir. 2003); *Artis v. Corona Corp. of Japan*, 703 A.2d 1214, 1217 (D.C. Cir. 1997); *McDaniel v. Trail King Indus., Inc.*, 248 F. Supp. 2d 749, 757 (N.D. Ill. 2002).

193. *Boatland*, 609 S.W.2d at 745.

194. *Id.*

195. *Id.*

196. *Id.* at 746.

197. *Id.* at 745.

198. *Id.* at 746.

According to the court, the feasibility of a safer alternative could be shown by evidence that it was used by or available to, the industry at the time of manufacture.¹⁹⁹ The plaintiff could also show that a safer alternative design was feasible by providing evidence that the industry had the economic and technological capacity to develop this alternative.²⁰⁰

In *Boatland*, the plaintiff's experts stated that the concepts behind kill switches were not new and that homemade kill switches had been used on racing boats for more than thirty years.²⁰¹ However, the defendant responded that kill switches for boats were not *commercially* available at the time of the accident.²⁰² Based on this evidence, the court concluded that while it was technologically possible to fabricate a kill switch at the time of the accident, it was not feasible for the defendant to have installed one on Bailey's boat at the time of sale because they were not available for purchase to the trade at that time.²⁰³ Accordingly, the Texas Supreme Court reversed the intermediate appellate court and affirmed the trial court's judgment for the defendant.²⁰⁴

Although the *Boatland* court's holding about commercial feasibility seems correct, it should be noted that the defendant in that case was a retail seller, not a manufacturer, and apparently assembled boats to meet the needs of individual customers.²⁰⁵ Therefore, unlike large-scale boat manufacturers, Boatland probably could not have developed a kill switch on its own, but instead had no choice but to wait for them to become available commercially.

C. Procedural Effects

One of the most basic procedural issues is whether a court will admit state-of-the-art evidence at all. As discussed earlier, some courts consider state-of-the-art to inject negative principles and as a result, have refused to allow the parties to use such evidence in strict liability cases, even when defined in terms of technological feasibility.²⁰⁶ Presently, however, the great majority of courts permit either party to submit state-of-the-art evidence to prove that a product either was, or was not, defectively designed.²⁰⁷ A number of state statutes also

199. *Id.*

200. *Id.*

201. *Id.* at 747.

202. *Id.*

203. *Id.* at 749.

204. *Id.* at 750.

205. *Id.* at 752 (Campbell, J., dissenting).

206. See, e.g., *Dart v. Wiebe Mfg., Inc.*, 709 P.2d 876, 881-82 (Ariz. 1985); *Matthews v. Stewart Warner Corp.*, 314 N.E.2d 683, 692 (Ill. App. Ct. 1974); *Gelsumino v. E.W. Bliss Co.*, 295 N.E.2d 110, 113 (Ill. App. Ct. 1973); *Cryts v. Ford Motor Co.*, 571 S.W.2d 683, 689 (Mo. Ct. App. 1978); *Carreter v. Colson Equip. Co.*, 499 A.2d 326, 329 (Pa. Super. Ct. 1985).

207. See, e.g., *Reed v. Tiffin Motor Homes, Inc.*, 697 F.2d 1192, 1198 (4th Cir. 1982); *Caterpillar Tractor Co. v. Beck*, 593 P.2d 871, 887 (Alaska 1979), *superseded by statute as stated in Smith v. Ingersoll-Rand Co.*, 14 P.3d 990 (Alaska 2000); *Gosewisch v. Am. Honda Motor Co.*,

provide for the admission of state-of-the-art evidence.²⁰⁸

Nevertheless, courts differ on how state-of-the-art evidence may be used. For example, some courts only allow defendants to introduce state-of-the-art evidence to rebut testimony by the plaintiff.²⁰⁹ Thus, in *Murphy v. Chestnut Mountain Lodge, Inc.*, the court ruled that once the plaintiff alleged certain anti-friction devices for skis were available and within state-of-the-art, the defendant would be allowed to rebut this claim by showing that the devices proposed by the plaintiff were ineffective.²¹⁰ Other courts seem to put the burden on the defendant to prove that its product complied with state-of-the-art at the time it was manufactured.²¹¹ This is also true of some state statutes.²¹²

Placement of the burden of proof, as opposed to the burden of production, seems to depend on whether compliance with state-of-the-art is regarded as an affirmative defense or not. Under the traditional approach, the plaintiff has the burden of proving that the product is defective.²¹³ If the plaintiff makes a prima facie case, usually by submitting evidence of a safer alternative design, the defendant will usually respond by arguing that the proposed alternative design is “not within the state of the art.”²¹⁴ Failure on the part of the defendant to effectively respond to the plaintiff’s evidence of feasibility will probably result

737 P.2d 365, 370 (Ariz. Ct. App. 1985), *opinion vacated in part by* 737 P.2d 376 (Ariz. 1987); *Hughes v. Massey-Ferguson, Inc.*, 522 N.W.2d 294, 296-98 (Iowa 1994); *Wiska v. St. Stanislaus Soc. Club, Inc.*, 390 N.E.2d 1133, 1138 (Mass. App. Ct. 1979); *Lancaster Silo & Block Co. v. N. Propane Gas Co.*, 427 N.Y.S.2d 1009, 1016 (App. Div. 1980); *Bolm v. Triumph Corp.*, 422 N.Y.S.2d 969, 974-75 (App. Div. 1979); *Boatland*, 609 S.W.2d at 749; *Cantu v. John Deere Co.*, 603 P.2d 839, 841 (Wash. Ct. App. 1979).

208. See FLA. STAT. ANN. § 768.1257 (West 2012); MICH. COMP. LAWS ANN. § 600.2946 (West 2012), *recognized as unconstitutional by* *White v. Smith Kline Beecham Corp.*, 538 F. Supp. 2d 1023 (W.D. Mich. 2008); S.D. CODIFIED LAWS § 20-9-10.1 (2011); TENN. CODE ANN. § 29-28-105 (West 2012); WASH. REV. CODE ANN. § 7.72.050 (West 2012).

209. See *Murphy v. Chestnut Mountain Lodge, Inc.*, 464 N.E.2d 818, 823-24 (Ill. App. Ct. 1984); *Boatland*, 609 S.W.2d at 749; *Cantu*, 603 P.2d at 841.

210. *Murphy*, 464 N.E.2d at 823-24.

211. See *O’Brien v. Muskin Corp.*, 463 A.2d 298, 305 (N.J. 1983), *superseded by statute as stated in* *Dewey v. R.J. Reynolds Tobacco Co.*, 577 A.2d 1239 (N.J. 1990). *But see* *Fabian v. Minster Mach. Co.*, 609 A.2d 487, 494 (N.J. Super. Ct. App. Div. 1992) (holding that plaintiff has the burden of proving nonconformity with state-of-the-art).

212. ARIZ. REV. STAT. ANN. § 12-683(1) (2012); IOWA CODE ANN. § 668.12 (West 2012); LA. REV. STAT. ANN. § 9:2800.59(3) (West 2012); MO. ANN. STAT. § 537.764(2) (2012); NEB. REV. STAT. § 25-21,182 (2011); N.H. REV. STAT. ANN. § 507:8-g (2011).

213. See, e.g., *Prentis v. Yale Mfg. Co.*, 365 N.W.2d 176, 181-82 (Mich. 1984) (declaring that “the plaintiff must, in every case, in every jurisdiction, show that the product was defective”).

214. See *Boatland*, 609 S.W.2d at 749; *Cantu*, 603 P.2d at 841. In addition, a number of states have enacted statutes that create a state-of-the-art affirmative defense, thereby requiring the defendant to prove that a proposed alternative design was not within the state-of-the-art. See *supra* note 212.

in a verdict for the plaintiff.²¹⁵

Furthermore, most courts hold that compliance with state-of-the-art is not a complete defense, but merely a relevant factor for the jury to consider.²¹⁶ As far as proof is concerned, an Arizona court in *Gosewisch v. American Honda Motor Co.*²¹⁷ identified several forms of proof that a defendant could offer to determine state-of-the-art. *Gosewisch* involved a three-wheeled All Terrain Cycle (ATC), which flipped over and injured the plaintiff.²¹⁸ The plaintiff argued the ATC was defectively designed because it was equipped with very low-pressured, collapsible tires, it lacked a mechanical suspension, was inherently unstable because of its high center of gravity, had weak front forks, and its front brake was prone to accidental engagement.²¹⁹ The court declared that the manufacturer could show state-of-the-art by offering evidence about the thoroughness of its testing and research prior to manufacture.²²⁰ The manufacturer presented evidence that the ATC model in question was thoroughly tested in the laboratory and with test riders, including novices, who rode the vehicle over “some of the most diverse terrain in the world.”²²¹ The court also pointed out that state-of-the-art can be established by demonstrating the infeasibility of each of the testing and design alternatives proposed by the plaintiff.²²²

In this case, the defendant offered evidence to rebut the plaintiff’s claims that it should have used computer simulations to test the safety of its ATC.²²³ The defendant responded by showing “that computer simulations could not account for the variables involved in a rider-active vehicle.”²²⁴ The plaintiff also maintained that mechanical suspension should have been included in the ATC.²²⁵ However, the defendant’s experts tested ATCs with the type of mechanical suspensions suggested by the plaintiffs and concluded that their handling was inferior to the defendant’s vehicles.²²⁶ In addition, the front forks in the original design proved to be stronger than the replacement forks proposed by the

215. See *Rucker v. Norfolk & W. Ry. Co.*, 381 N.E.2d 715, 725 (Ill. App. Ct. 1978), *rev’d on other grounds*, 396 N.E.2d 534 (Ill. 1979).

216. See, e.g., *Caterpillar Tractor Co. v. Beck*, 593 P.2d 871, 887 (Alaska 1979), *superseded by statute as stated in* *Smith v. Ingersoll-Rand Co.*, 14 P.3d 990 (Alaska 2000); *O’Brien*, 463 A.2d at 305; *Crispin v. Volkswagenwerk AG*, 591 A.2d 966, 973 (N.J. Super. Ct. App. Div. 1991); *Patterson v. Ravens-Metal Prods., Inc.*, 594 N.E.2d 153, 161-62 (Ohio Ct. App. 1991); *Owens-Corning Fiberglass Corp. v. District Court (Caldwell)*, 818 S.W.2d 749, 752 (Tex. 1991).

217. 737 P.2d 365 (Ariz. Ct. App. 1985), *opinion vacated in part by* 737 P.2d 376 (Ariz. 1987).

218. *Id.* at 367.

219. *Id.*

220. *Id.* at 370.

221. *Id.*

222. *Id.*

223. *Id.*

224. *Id.*

225. *Id.*

226. *Id.*

plaintiff.²²⁷ Finally, the defendant provided comparisons of its tires with those suggested by the plaintiff.²²⁸ All of this state-of-the-art evidence persuaded the jury to conclude that the ATC was not defective.²²⁹

The various applications of the state-of-the-art concept discussed above are confusing to say the least. The best approach to use would seem to be the following: The Plaintiff must show that the product is defective in design by proposing an alternative design that is technologically feasible. The defendant can then try to rebut the plaintiff's claim by showing that the alternative design is not technologically or commercially feasible.

D. Products Liability Restatement

Section 2(b) of the *Products Liability Restatement*, which defines defective design, does not specifically mention state-of-the-art. Commentary in section 2 does discuss the state-of-the-art concept, but its analysis is somewhat unclear. After acknowledging that the term state-of-the-art has a number of different meanings, the comment declares that if the defendant can show the existing design of “its product was the safest in use at the time of sale, it may be difficult for the plaintiff to prove that an alternative design could have been practically adopted.”²³⁰ In other words, the quality of the *defendant's* design is offered as proof that the plaintiff's alternative design was not feasible. However, the comment then seems to equate state-of-the-art with industry practice by declaring that “[t]he defendant is thus allowed to introduce evidence with regard to industry practice that bears on whether an alternative design was practicable.”²³¹ Commentary also suggests that industry practice may be relevant to the issue of whether the defendant's failure to adopt a safer alternative design caused the product to be “not reasonably safe.”²³² It is also suggested that evidence of industry practice is admissible, but not necessarily dispositive.²³³ According to the commentary, if the plaintiff introduces expert testimony that a reasonable alternative design was practical and could have been adopted by the defendant, then the trier of fact may seemingly conclude that the product was defective even though no one in the industry had adopted, or even considered adopting, the alternative design at the time of sale.

Further commentary lists the various factors that the fact-finder may take into account in determining whether a proposed alternative design is reasonable.²³⁴ For the most part, these factors are not weighted in any way and appear to be

227. *Id.*

228. *Id.*

229. *Id.* at 367.

230. RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2 cmt. d, at 20 (1998).

231. *Id.*

232. *Id.*

233. *Id.*

234. *Id.* cmt. f.

nothing more than a laundry list, originally formulated by Dean John Wade²³⁵ that courts have taken into account to determine whether a product's utility, as designed, outweighs its risks. In its discussion of these factors, the *Restatement* notes that the relative advantages and disadvantages of the product as designed, and as it could have been designed, may be considered, including the effects of an alternative design on longevity production, maintenance, and repair costs.²³⁶ The listing of these factors seems to suggest that any alternative design proposed by the plaintiff must be feasible in order to meet the *Restatement's* reasonableness requirement.

II. TECHNOLOGICAL DEVELOPMENT

The foregoing discussion concluded that courts generally associate state-of-the-art concept with technological feasibility. The issue of technological feasibility often arises in connection with evidence of a safer alternative design offered by the plaintiff. Although courts generally agree that an alternative design must be technologically feasible in order to be within state-of-the-art, they also point out that an alternative design does not necessarily have to be in existence when the product in question is originally marketed, so long as it was technologically feasible to produce it at that time. However, this approach may be inappropriate when technological development in a particular area is dependent upon developments in other industries. In other words, it is not always correct to assume that industry necessarily controls the pace of technological development. The following discussion will describe the various ways in which technology develops.

A. Linear Development

With the exception of products that are discovered entirely by accident, such as penicillin²³⁷ or vulcanized rubber,²³⁸ most technologies develop over time in either a linear fashion or an interdependent fashion. The linear model usually involves an established technology that is further developed over time without significant interaction with any other technology.²³⁹ Some examples of this model include violins from Brescia and Cremona and mid-nineteenth century clipper ships developed for the China tea trade.

1. *Violins*.—One example of linear development comes from the golden age of violin making in northern Italy from 1550 to 1750.²⁴⁰ Violin makers (or luthiers) of that period changed the basic design of the violin only slightly,

235. See John W. Wade, *On the Nature of Strict Tort Liability for Products*, 44 MISS. L.J. 825, 837-38 (1973).

236. RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2, cmt. f, at 22-25.

237. See BURKE, PINBALL EFFECT, *supra* note 10, at 118-19.

238. *Id.* at 46.

239. See *supra* pages 670-71 and accompanying footnotes.

240. See William Bartruff, *The History of the Violin*, BARTRUFF, <http://www.bartruff.com/history/> (last visited Feb. 7, 2012) (providing a history of early violin makers) [hereinafter *Bartruff*].

although they did experiment with various woods, glues, and varnishes to improve the quality and sound of their instruments.²⁴¹ The oldest existing instrument is one of a set of twelve constructed by Andrea Amati for the French King, Charles IX, in 1560.²⁴² To the casual observer, this violin looks very much like a contemporary instrument. The basic sound of the violin did not change dramatically over the years either.²⁴³ Nevertheless, the luthiers of Brescia and Cremona did make changes in the construction of their instruments.²⁴⁴ For example, Andrea Amati's sons, Antonio and Girolamo, perfected the shape of the violin's *f*-holes in the early seventeenth century.²⁴⁵ In the late seventeenth century, Antonio Stradivari began to cut a more distinct bevel and also began to outline the heads of his instruments in black.²⁴⁶ Later, Stradivari began to make his violins in a larger pattern than before and also began to use a darker, richer varnish to improve the appearance and tone of his instruments.²⁴⁷ As these examples suggest, violin technology was perfected by Italian craftsmen over the course of two centuries by small incremental changes without any significant technological innovation.

2. *Clipper Ships*.—Another example of linear technological development is the evolution of the clipper ship. In 1833, the East India Company lost its monopoly over the China tea trade, thereby creating an opportunity for the ships of other countries to transport tea from China to Great Britain.²⁴⁸ Since the tea-drinking public of that time believed that tea was better when it was fresh, speed became a greater consideration than it had been previously.²⁴⁹ The design for tea

241. *See id.*

242. *Id.*

243. For example, it is interesting to note that violin virtuoso, Ole Bull, used an instrument built by Gasparo da Salo in 1574 in thousands of concerts between 1840 and 1880. *See History of the Violin*, CLASSIC VIOLINSHOP.COM, <http://classicviolinshop.com/ArticleView.asp?ArticleID=1> (last visited Mar. 9, 2012). The sound of Bull's sixteenth century instrument apparently did not sound out-of-place to the ears of his nineteenth century audience. *See id.* (noting the popularity of da Salo's violin).

244. *See Bartruff, supra* note 240.

245. *Amati Family Violins*, THE OLD VIOLIN, <http://www.collectibleviolins.com/amati.html> (last visited Mar. 9, 2012).

246. Marshall C. St. John, *Chapter Two, Stradivari's Violins*, ANTONIO STRADIVARI, <http://www.cello.org/heaven/hill/two.htm> (last visited Mar. 9, 2012).

247. *See id.*

248. *See DERRY & WILLIAMS, supra* note 1, at 367.

249. *See id.* Prior to the mid-nineteenth century, tea and other commodities from the Far East were transported by East Indiamen. These well-armed sailing ships averaged only five or six knots an hour. *See* STEPHEN TAYLOR, *STORM AND CONQUEST: THE CLASH OF EMPIRES IN THE EASTERN SEAS*, 1809, at 58 (2007). Furthermore, they often “snuggled down” by reducing sail during the night. *DERRY & WILLIAMS, supra* note 1, at 367; *see also* BRIAN GARDNER, *THE EAST INDIA COMPANY: A HISTORY* 98 (1971). As a result, it took almost two years to complete a voyage from the Far East to Great Britain. *See DERRY & WILLIAMS, supra* note 1, at 365 (noting ships “would complete three voyages in six years”).

clippers may have originated in two-masted schooners developed in the United States for privateering during the War of 1812.²⁵⁰ In any event, by the mid-nineteenth century, clipper ships were much larger—exceeding 2000 tons and were built to get the most out of the light winds of the China seas.²⁵¹ The *Ariel*, which sailed from China to London in ninety-nine days, provides a good example of mid-nineteenth century clipper ship design.²⁵² The ship had three masts with four sails on the foremast, five sails on the mainmast, and four sails on the mizzenmast.²⁵³ It was 197 feet long with a beam of about thirty-four feet.²⁵⁴ It was “built of teak planking laid over iron frames” and relied on iron masts to support the pressure exerted on its sails.²⁵⁵ The *Ariel* averaged fourteen knots per hour at full sail.²⁵⁶ During the heyday of tea clippers, American and English shipbuilders competed with each other to build the fastest ships.²⁵⁷ However, they did not change the clipper’s basic design and most of their improvements were subtle and barely noticeable.²⁵⁸

B. The Ping-Pong Model

Sometimes two technologies develop in tandem, with one reacting to the other. For example, this sort of interaction occurred in the sixteenth century between warships and naval artillery.²⁵⁹ At the beginning of the sixteenth century, the carrack represented the ultimate in shipbuilding technology.²⁶⁰ The carrack was about 100 feet long with a beam of forty feet and a displacement of 600 to 800 tons.²⁶¹ It was a three-masted, fully rigged vessel with a foremast and

250. See DERRY & WILLIAMS, *supra* note 1, at 367.

251. *Id.* at 368.

252. *See id.*

253. *Id.* fig.172.

254. *Id.*

255. *Id.* at 368-69.

256. *Id.* at 368.

257. *See id.* at 364-70.

258. *See id.*

259. See ANGUS KONSTAM, *SOVEREIGNS OF THE SEA: THE QUEST TO BUILD THE PERFECT RENAISSANCE BATTLESHIP* 128 (2008).

260. Another vessel, popular at this time, was the caravel. Of Islamic origin, the caravel was used by Portuguese explorers in the fifteenth century to map the west coast of Africa. See ARCHIBALD R. LEWIS & TIMOTHY J. RUNYAN, *EUROPEAN NAVAL AND MARITIME HISTORY*, 300-1500, at 159 (1985). Carvel-built, the caravel usually had two masts that were fitted with lateen sails. *Id.* The ship was small, but maneuverable and easy to operate. *Id.* Two of the ships that accompanied Columbus on his first voyage to America, the *Niña* and the *Pinta*, were caravels of fifty to sixty tons displacement. *Id.* The larger *Santa Maria* was probably a *nao*, a larger vessel, also of Portuguese origin, that was somewhat similar to a carrack. See KONSTAM, *supra* note 259, at 176. However, it should be noted that some historians believe that the *Santa Maria* was actually a carrack. See, e.g., LEWIS & RUNYAN, *supra*, at 159.

261. See KONSTAM, *supra* note 259, at 38. Carracks could be either clinker-built or carvel-

mainmast, fitted with square mainsails and topsails, and a mizzenmast, which carried a triangular lateen sail.²⁶² Carracks typically also had a bowsprit sail on front²⁶³ and they were known for their very high forecastle and sterncastle structures.²⁶⁴

Their roomy hulls and wide beams made carracks excellent cargo vessels, but they were also used as warships.²⁶⁵ In the fifteenth and early sixteenth century, carrack warships were usually equipped with a few breech-loading iron cannons, along with a much larger number of smaller weapons mounted on the forecastle and sterncastle decks.²⁶⁶ The heavy guns of this period were not very powerful because their principal function was to assist in boarding enemy ships by disabling their rigging rather than trying to sink them.²⁶⁷ Heavy cannons of the day were made of wrought iron bars welded together into a tube and reinforced with iron hoops.²⁶⁸ They were breech loading because it was not possible at that time to fabricate muzzle loading cannons without casting them.²⁶⁹ These iron cannons generally fired stone cannonballs and had an effective range of only seventy-five yards.²⁷⁰

Several developments of significance occurred in the early sixteenth century that eventually led to the replacement of the carrack by its more effective successor, the galleon. The first innovation was the gunport.²⁷¹ This involved the cutting of ports or openings (with waterproof covers) into the hull of the ship, as opposed to the superstructure, so that heavy cannons could be placed on the main deck.²⁷² This not only allowed ship designers to add more guns, it also enabled them to use heavier artillery pieces without adversely affecting the vessel's stability.²⁷³ During the same time period, two other developments greatly increased the firepower of large guns. First, ship designers began to phase out breech-loading wrought iron cannons and replaced them with muzzle-loading cast bronze guns.²⁷⁴ These weapons had a range of 400 yards and could

built. *See id.* at 40.

262. *Id.* at 69. Some carracks had a fourth mast, known as a bonaventure mast, which also carried a lateen sail. *Id.*

263. *See* LEWIS & RUNYAN, *supra* note 260, at 158.

264. *See* KONSTAM, *supra* note 259, at 38.

265. *See* JAMES BURKE, CONNECTIONS 189 (1978) [hereinafter BURKE, CONNECTIONS].

266. For example, when Henry VII's warship, Sovereign, was launched in 1488, she was equipped with thirty-two heavy wrought iron cannons and 110 swivel guns designed for close range anti-personnel use. *See* KONSTAM, *supra* note 259, at 41.

267. *Id.* at 43-44.

268. *See* CARLO M. CIPOLLA, GUNS, SAILS AND EMPIRES: TECHNOLOGICAL INNOVATION AND THE EARLY PHASES OF EUROPEAN EXPANSION 1400-1700, at 23 (1965).

269. *Id.* at 24 n.1.

270. *See* KONSTAM, *supra* note 259, at 41.

271. *See* JEREMY BLACK, TOOLS OF WAR 72 (2007).

272. *Id.*

273. *See* CIPOLLA, *supra* note 268, at 82.

274. *See* BLACK, *supra* note 271, at 90.

fire up to a sixty pound shot.²⁷⁵ Firepower was also increased by the replacement of stone shot with iron cannonballs, which had much greater penetrating power.²⁷⁶

However, even with these improvements in ship design and armament, the carrack had serious deficiencies as a warship. First of all, the improvements in gunnery made carracks easy targets because of their high profile.²⁷⁷ Moreover, their height also made them top-heavy and vulnerable to rolling, which reduced the accuracy of their gunfire.²⁷⁸ Finally, carracks, with their high superstructures, were difficult to handle “as the wind tended to push them to leeward as they sailed,” making it difficult to keep a straight course.²⁷⁹

In the 1530s, Spanish and Portuguese shipbuilders searched for a design that would combine “the speed and maneuverability of the [carrack] with the cargo capacity of the” carrack.²⁸⁰ The result was that icon of pirate movies, the Spanish galleon. Unlike the carrack, the galleon was purpose-built as a warship, primarily to protect Spanish treasure ships returning to Europe from the Americas.²⁸¹ Galleons were narrower than carracks, with a typical length-to-beam ratio of 4-to-1, as compared with the 3.5-to-1 ratio for carracks.²⁸² This made for greater speed and better handling.²⁸³ The earliest galleons were rather small, about 350 tons, but gradually increased in size during the course of the sixteenth century.²⁸⁴

The next development in ship design occurred in England (which was not yet Great Britain) in 1570 when a master shipwright, Richard Chapman, teamed up with an ex-pirate and slave trader, Sir John Hawkins, to produce the first race-built galleon, a 300-ton vessel called the Foresight.²⁸⁵ The ship had a sleek hull,

275. See KONSTAM, *supra* note 259, at 43. These bronze cannons came in various sizes. For example, a curtow could fire a sixty pound ball; a demi-curtow could fire a thirty pound ball; and a culverin could fire a twenty pound shot. *Id.*

276. See BLACK, *supra* note 271, at 90.

277. KONSTAM, *supra* note 259, at 175.

278. *Id.*

279. *Id.*

280. *Id.* at 176.

281. *Id.* at 180. The need for protection was demonstrated by an encounter off the southwest coast of Portugal in 1523. Three Spanish caravels, sailing without an escort and loaded with treasure from South America, were overhauled and captured by French privateers, resulting in a severe financial loss to the Spanish Crown. *Id.* at 177-78.

282. *Id.* at 181.

283. See *id.*

284. *Id.* at 181-82. Portuguese galleons tended to be larger, sometimes reaching 1000 tons displacement. *Id.* at 182.

285. *Id.* at 188. In 1568, while commanding an ancient carrack, the Jesus of Lubeck, Hawkins, accompanied by his young cousin, Francis Drake, had an opportunity to compare first hand the fighting qualities of these two kinds of ships and barely escaped with his life. See ERNLE BRADFORD, *DRAKE* 45-59 (1965). Many crewmembers were forced to surrender to the Spanish after the ship was destroyed. *Id.* at 57. One of the scenes from Errol Flynn's 1940 film, *The Sea*

with a relatively deep draft, a low superstructure, a long beak in front, and a narrow stern. The foremast was placed farther forward than normal and slanted forward slightly, which improved the vessel’s handling.²⁸⁶ Heavily armed for its size, the Foresight carried twenty-eight heavy bronze muzzle-loading cannons arrayed on one continuous gundeck.²⁸⁷ Faster, more maneuverable, and more heavily armed than Spanish warships, race-built galleons proved their worth when war finally broke out between England and Spain in 1588.²⁸⁸

C. The Pinball Model

Technological development often follows a path where changes are interdependently linked. In other words, technological change does not occur in a vacuum, but relies on developments in other fields.²⁸⁹ Three historical examples help to illustrate this process: the printing press, the railroad, and the automobile.

1. *Printing.*—The development of printing required innovations in at least four areas, the press, paper, oil-based ink, and movable metal type.²⁹⁰ The printing press itself was easily adapted from the linen and paper presses of the time.²⁹¹ However, another innovation, paper, was also necessary to the development of printing. Prior to the introduction of paper in Europe, the only material available was parchment, which was made from the skins of sheep. A 200 quarto-page codex would require the skins of twelve sheep, which was very expensive and also hard on the sheep.²⁹² Of Chinese origin, paper was introduced into Spain by the Moors in the twelfth century, and had spread to the rest of Europe by the fourteenth century.²⁹³ High-quality paper could be made from discarded linen. Fortunately, most of the population was able to afford linen undergarments by the fourteenth century because the Black Death had caused wages to rise sharply.²⁹⁴ This meant that worn out linen clothing could be collected by itinerant “rag-and-bone” men and sold to paper mills.²⁹⁵ Paper,

Hawk, was loosely based on this incident. For general information regarding *The Sea Hawk*, see *The Sea Hawk*, IMDB, <http://www.imdb.com/title/tt0033028/> (last visited May 1, 2012).

286. KONSTAM, *supra* note 259, at 188-89.

287. *Id.* at 189.

288. *See id.* at 198-203.

289. *See* BURKE, PINBALL EFFECT, *supra* note 10, at 36.

290. DIANA CHILDRESS, JOHANNES GUTENBERG AND THE PRINTING PRESS 60 (2008) (describing Gutenberg’s contributions to the printing press).

291. *See* DERRY & WILLIAMS, *supra* note 1, at 236.

292. *See id.* at 232. In ancient times, sheets of parchment were sewn together to produce lengthy documents, which were then rolled up for storage. *Id.* Around the second century A.D. scribes began to fold rectangular sheets of parchment into pages and then bound them together to form a codex or book. *Id.*

293. *Id.* at 232-33.

294. *See* BURKE, CONNECTIONS, *supra* note 265, at 100.

295. *See id.*

produced by water-powered mills, was much cheaper than parchment.²⁹⁶

Another piece of the puzzle was the invention of movable metal type by Johann Gutenberg in the mid-fifteenth century. Prior to that time, wood blocks had been used in Europe to print playing cards, calendars and prayers.²⁹⁷ However, wood blocks were expensive to carve and wore out quickly.²⁹⁸ Gutenberg's solution was to manufacture a movable type that was durable, that would be uniform in size and that would lie side-by-side in a holder so as to produce an even line of print.²⁹⁹ Furthermore, movable type could be used repeatedly, and when a letter wore out, a new one could be reproduced in a mold.³⁰⁰ Interchangeability of type required standardization of the size and shape of the letters, greatly enhancing readability.³⁰¹ Not surprisingly, printing spread rapidly throughout Europe during the late fifteenth century.³⁰²

The final requirement for the commercialization of printing was the development of a suitable ink. At first printers used a water-based ink similar to that used by scribes to copy manuscripts.³⁰³ However, because of its low viscosity, this type of ink made a poor impression on the absorbent paper that was required for printing.³⁰⁴ As a result, the impression was often smudged and showed through the opposite side of the page.³⁰⁵ Fortunately, these problems were eventually solved with the introduction of an oil-based ink which was made by combining linseed oil with lampblack or powdered charcoal.³⁰⁶

2. *Railroads.*—The development of the railroad was made possible, first and foremost, by the invention of the steam engine. Originally developed to pump water from coal mines, this versatile device was adapted for many uses in the nineteenth century.³⁰⁷ However, the steam engine took a long time to develop and many other technologies were essential to its use as a power source for railroads. The first requirement was an understanding of the principles of atmospheric pressure and vacuums.³⁰⁸ The second was to apply these principles to a piston and cylinder mechanism in order to produce power.³⁰⁹ The third

296. For example, as early as 1300, paper sold for one-sixth of the price of parchment. *Id.* at 101.

297. *See id.*

298. *Id.*

299. *Id.* at 102. To create a letter of type, a steel punch was used to hammer the letter's impression into a copper matrix. *Id.* A lead alloy was poured into a mold in order to produce a piece of typeface that was raised on a shoulder and stalk of uniform height. *Id.*

300. *See* DERRY & WILLIAMS, *supra* note 1, at 237.

301. *See id.*

302. *See* BURKE, PINBALL EFFECT, *supra* note 10, at 274.

303. *See* DERRY & WILLIAMS, *supra* note 1, at 235.

304. *Id.* at 235-36.

305. *Id.*

306. *Id.* at 236.

307. *See id.* at 312.

308. *Id.* at 323-25.

309. *Id.* at 324-25.

breakthrough was the lathe-type boring machine and other machine tools (borrowed from clockmakers) that were necessary to fabricate steam engine parts to the precise specifications necessary to generate power efficiently.³¹⁰ The last requirement was the sun-and-planet gear, developed by James Watt, that converted the up-and-down motion of the piston to a rotary motion that could be used to drive wheels.³¹¹

The story begins in the mid-seventeenth century when scientists discovered that a vacuum could be produced when air pressure was allowed to drop in an enclosed space.³¹² This discovery was prompted by the fact that European silver and iron mines were being flooded because the suction pumps of the day could not lift water more than thirty-two feet.³¹³ Subsequent experiments by Otto von Guericke suggested that if a device could be made that would repeatedly create a vacuum, atmospheric pressure that could be used to operate a pump.³¹⁴ Some years later, Denis Papin put this principle to work by constructing a machine which used steam power to move a piston up and down in a cylinder.³¹⁵ In 1712, Thomas Newcomen applied this piston and cylinder concept to construct a steam powered pump that was installed at a coal mine in Straffordshire, England.³¹⁶ Finally, in 1765, James Watt greatly improved the efficiency of the Newcomen steam engine by adding a condenser so that water did not have to be sprayed directly into the cylinder to condense the steam.³¹⁷

The steam engine might have been limited to pumping water out of coal mines if it had not been for two other developments in the eighteenth century. The first was the invention of the sun-and-planet gear by James Watt in 1784.³¹⁸ This device allowed vertical motion of the piston and cylinder to be converted into a rotary motion, enabling steam engines to turn wheels carrying belts and

310. *Id.* at 322.

311. *Id.* at 323.

312. *See* BURKE, CONNECTIONS, *supra* note 265, at 75.

313. *See id.* at 72-73. Experiments by Evangelista Torricelli and Gasparo Berti in the 1640s established the existence of atmospheric pressure and showed that the weight of the air pressing down on a pool of water at the foot of a mineshaft prevented the water from rising more than thirty-two feet. BURKE, PINBALL EFFECT, *supra* note 10, at 133. Then in 1648, a group of French scientists climbed a mountain with a tube of mercury suspended in a dish of mercury. *See id.* at 134. As they climbed higher, the mercury level in the tube fell, indicating that atmospheric pressure was lessening. *Id.* This was expected; however, the scientists were surprised to find a space between the mercury and the top of the tube. *Id.* Since air could not enter the tube because it was blocked by the mercury, they concluded that the mysterious space in the tube could only be a vacuum. *Id.*

314. *See* DERRY & WILLIAMS, *supra* note 1, at 314.

315. *Id.* at 315.

316. CHRISTOPHER MCGOWAN, RAIL, STEAM AND SPEED: THE “ROCKET” AND THE BIRTH OF STEAM LOCOMOTION 39-40 (2004).

317. DERRY & WILLIAMS, *supra* note 1, at 320-21.

318. *Id.* at 323-24.

thereby operate machines in mills, breweries, and ironworks.³¹⁹ The second major innovation was John Wilkinson's lathe-type boring machine, originally developed in 1774 to bore bronze cannons.³²⁰ The cylinders in Watt's 1765 versions of steam engines needed to be constructed with great precision. However, this was not possible until 1775, when Wilkinson adapted his machine to bore cylinders for Watt's steam engines.³²¹ This set the stage for the development of railroads, steamships and steam-powered farm machinery in the nineteenth century.

The origins of the railroad can be traced to Richard Trevithick, who built a "steam carriage" known as Captain Dick's Puffer in 1801.³²² Unfortunately, the vehicle exploded four days after its debut because Trevithick forgot to turn off the boiler.³²³ In 1803, he built another steam carriage for use in London, but it was unable to cope with the poor roads of the time.³²⁴ This caused Trevithick to turn his attention to rail travel.³²⁵ The next year, he constructed a locomotive which transported a ten-ton load of cast iron from the Pen-y-darren Iron Works to the Glamorganshire Canal nine miles away at a speed of five miles per hour.³²⁶ Trevithick's last project was the 1808 steam locomotive Catch-me-who-can which briefly carried passengers along a circular track in London's Euston Square.³²⁷

Meanwhile, responding to the high cost of horse fodder caused by the Napoleonic wars, coal mine owners and textile manufacturers began to envision the railroad as a cheaper alternative to horse-drawn transportation.³²⁸ The first public railroad was the Stockton & Darlington Railway Company, founded in 1824 to transport coal from the Durham coal mines to the wharves of Stockton on the River Tees, about thirty miles away.³²⁹ Several years later, the Liverpool & Manchester Railway was formed to ship cotton goods from Manchester to the

319. See BURKE, PINBALL EFFECT, *supra* note 10, at 24.

320. *Id.* at 250.

321. DERRY & WILLIAMS, *supra* note 1, at 350. Unlike other steam engines, Watt's did not have a water seal on top of the piston because it would have cooled the cylinder down and reduced the steam engine's power; however, this meant that the cylinder and piston had to fit perfectly in order to prevent steam from escaping. See BURKE, CONNECTIONS, *supra* note 265, at 175.

322. See Richard Cavendish, *Richard Trevithick's First Steam Carriage*, 51 HISTORY TODAY (2001), available at www.historytoday.com/richard-cavendish/richard-trevithicks-first-steam-carriage; see also MCGOWAN, *supra* note 316, at 49-50. In 1769, Nicholas Cugnot, a French military officer, constructed a steam-powered wagon to haul field artillery. *Id.* at 50. It worked, but was so slow and inefficient that it was soon abandoned. See *id.*

323. *Id.*

324. *Id.* at 52.

325. *Id.*

326. *Id.* at 57-58.

327. *Id.*

328. See MCGOWAN, *supra* note 316, at 86.

329. See *id.* at 2-3.

seaport of Liverpool.³³⁰ Liverpool and Manchester held a series of trials at the village of Rainhill, near Liverpool, in October 1829 to determine who would supply them with locomotives.³³¹ The winner of this competition was a locomotive named Rocket, built by George Stephenson.³³² The secret of Rocket’s success was a system of copper tubes that Stephenson designed to carry hot water from the boiler through the hot gases escaping up the chimney from the firebox.³³³ The tubes provided a much greater heating surface and consequently generated more high pressure steam to drive the engine’s cylinders than the competition.³³⁴ The Liverpool & Manchester Railway began operation on September 15, 1830 with the Duke of Wellington as its reluctant guest of honor.³³⁵

Although the steam engine was critical to the development of the railroad, there were other elements as well. For example, developments in track construction greatly aided the development of the railroad. At first, railroads used cast iron rails, which had been developed for use in coal mines during the eighteenth century.³³⁶ However, cast iron rails were brittle and did not hold up well, leading to their replacement by wrought iron rails in 1830.³³⁷ Eventually, iron rails were replaced by steel rails.³³⁸ In addition to rail construction, the invention of the telegraph made it possible to safely run trains in opposite directions along the same track.³³⁹ Contemporaneous advances in bridge-building, such as the fabrication of iron and steel bridges, and developments in tunnel construction techniques also contributed to the commercial success of railroads in the nineteenth century.³⁴⁰

3. *Motor Vehicles.*—Like the printing press and the railroad, a number of technological developments had to occur before motor vehicles could be successfully introduced into the stream of commerce. Among these developments were the internal combustion engine, the carburetor, the spark plug, pneumatic rubber tires and gasoline fuel.

The motor vehicle’s most important feature is the internal combustion engine. Unlike a steam engine, which burns fuel externally in a firebox, an internal combustion engine burns fuel inside its cylinders.³⁴¹ First, a mixture of

330. *See id.* at 4.

331. *See id.* at 6-7, 221.

332. *Id.* at 221-22.

333. *Id.* at 181-82.

334. *See* BURKE, PINBALL EFFECT, *supra* note 10, at 70.

335. *See* MCGOWAN, *supra* note 316, at 73, 244-45. The Duke was not fond of rail travel. *See id.* at 73 (“[H]e abhorred the very idea of locomotives.”).

336. *See* DERRY & WILLIAMS, *supra* note 1, at 377-78.

337. *Id.* at 378.

338. *Id.* at 381.

339. *See* BURKE, PINBALL EFFECT, *supra* note 10, at 29.

340. *See* DERRY & WILLIAMS, *supra* note 1, at 448-62.

341. *Id.* at 602.

gasoline and air is sprayed into the cylinder and compressed by a piston.³⁴² At the point of maximum compression, an electrical spark ignites the fuel.³⁴³ The explosion produces hot gases which push the piston down.³⁴⁴ These combustion gases are then vented and more of the fuel-air mixture is injected to run a second stroke.³⁴⁵ Valves control the intake of the fuel-air mixture and vent exhaust gases at the appropriate time in the cycle.³⁴⁶

The basic concept of the internal combustion engine was not new at the turn of the nineteenth century. As early as the seventeenth century, Denis Papin (mentioned earlier in connection with the development of the steam engine) experimented with a device to produce power from exploding gunpowder.³⁴⁷ It was not much of a success.³⁴⁸ In 1859, Étienne Lenoir invented a stationary internal combustion engine that used an electric spark to ignite a mixture of coal gas and air.³⁴⁹ Finally, in 1876, Nikolaus Otto patented a four-stroke engine which he modestly called the Otto Cycle Engine.³⁵⁰ This engine, with subsequent improvements developed by Gottlieb Daimler and Wilhelm Maybach, became the standard power source for gasoline-powered motor vehicles in the twentieth century.³⁵¹

However, a number of other inventions also contributed to the successful operation of motor vehicles. One such device was the carburetor, invented by Maybach in 1893, used to spray the right amount of air and fuel into the cylinder.³⁵² This gadget was based on mid-nineteenth century perfume atomizers, which used a drop in air pressure to convert a liquid into a fine mist.³⁵³ This phenomenon is known as the Venturi Effect.³⁵⁴ Another invention was the spark plug, which can be traced back to Alessandro Volta's eudiometric pistol.³⁵⁵ This device, developed in 1776, consisted of a glass pistol-like container filled with gas and corked at one end.³⁵⁶ A spark resulted inside the pistol when Volta touched one of two electrically charged wires, inserted into the pistol, while making contact with the other wire and the pistol's electrophore lid.³⁵⁷ Volta unknowingly made another contribution to the development of the automobile by

342. *Id.*

343. *Id.*

344. *Id.*

345. *Id.*

346. *Id.*

347. *Id.* at 600.

348. *See id.*

349. *Id.* at 601-02.

350. *Id.* at 602-03.

351. *Id.* at 605.

352. BURKE, PINBALL EFFECT, *supra* note 10, at 109-10.

353. *See* BURKE, CONNECTIONS, *supra* note 265, at 181-82.

354. *Id.*

355. *See id.* at 178-79.

356. *Id.*

357. *Id.* at 178.

inventing a chemical fuel cell, the prototype of the rechargeable car battery.³⁵⁸

Another vital component to the development of the motor vehicle was the pneumatic rubber tire. In 1839, Charles Goodyear discovered the process of vulcanization by which natural rubber was toughened by being heated in a mixture of sulfur and white lead.³⁵⁹ In 1846, Thomas Hancock began manufacturing solid rubber road tires for horse-drawn carriages.³⁶⁰ Pneumatic rubber tires also appeared at this time, but were not a commercial success.³⁶¹ In 1888, J.B. Dunlop, an Irish surgeon, developed pneumatic rubber tires for bicycles.³⁶² Dunlop's invention came along at just the right time to serve the needs of the newly-developed automobile.³⁶³

The final requirement was to find a suitable fuel to power the automobile's internal combustion engine. The solution was a petroleum product called gasoline. Oil was first discovered by Edwin Drake in Pennsylvania in 1859.³⁶⁴ It could be distilled into various components for use in heating, lighting or lubrication.³⁶⁵ At first, the lighter, more volatile products of the distillation process were thrown away as waste.³⁶⁶ However, toward the end of the nineteenth century, this waste product, now known as gasoline, was found to be the perfect fuel to power the newly-developed automobile.³⁶⁷ More than a century later, gasoline-powered motor vehicles remain the principal means of transportation in the world.

4. *Modern Technologies.*—The interdependent model of technological development is not limited to the nineteenth century and earlier; it is also applicable to more modern inventions such as personal computers, cellular telephones, and global positioning systems.

Various technologies have contributed to the development of the personal computer. For example, computers require one or more Central Processing Units (CPU) or microprocessors in order to execute software instructions.³⁶⁸ Software includes application software which is used to carry out tasks such as word processing, sending and receiving e-mail, internet browsing, faxing, and playing computer games. In addition, computers also require system software, which interfaces with hardware to support application software.³⁶⁹ All of this software

358. See BURKE, PINBALL EFFECT, *supra* note 10, at 146-47.

359. *Id.* at 46.

360. See DERRY & WILLIAMS, *supra* note 1, at 528-29.

361. *Id.* at 529.

362. *Id.* at 392.

363. *Id.*

364. BURKE, CONNECTIONS, *supra* note 265, at 179.

365. *Id.* at 179-80.

366. *Id.* at 180.

367. *See id.*

368. *The Central Processing Unit*, COMPUTER SPECIALIST, <http://www.ispcp.org/the-central-processing-unit.html> (last visited May 2, 2012).

369. *See How Computers Work—Software*, STAN. U., <http://www.stanford.edu/class/cs101/how-computers-work-software.html> (last visited May 3, 2012) (discussing programs and operating

relies on a language system of ones and zeroes called binary code. Binary code was derived from office tabulators and calculators, which in turn adapted it from the Jacquard loom.³⁷⁰ The computer keyboard is descended from the typewriter keyboard.³⁷¹ The monitor was originally based on cathode ray tube technology, which was also used in television and medical monitoring machines.³⁷²

Mobile telephones, especially modern smart phones, also incorporate many distinct technologies. The most important of these technologies is voice radio transmission, which originated with ship-to-shore transmissions by Reginald Fessenden in the early twentieth century.³⁷³ All mobile telephones are powered by a rechargeable battery, which can be traced back to Alessandro Volta's experiments with chemical batteries in the late eighteenth century.³⁷⁴ Mobile telephones also have a CPU similar to that of a computer to run all of the telephone's software.³⁷⁵ Additionally, modern smart phones rely on many other technological innovations to play music, take photographs, download video and audio data, send and receive text messages and email, and access the Internet.³⁷⁶ Obviously, if these technologies had not already been in place when mobile telephones came on the scene, the mobile telephone that emerged would look very different from today's version.

The global positioning system (GPS), maintained by the United States Government, provides highly accurate location and time information for airplanes, cars, boats, submarines and even pedestrians.³⁷⁷ The system was developed in 1973 and became fully operational in 1994.³⁷⁸ The technologies

systems).

370. See BURKE, CONNECTIONS, *supra* note 265, at 108-13.

371. See TYPING THROUGH TIME: KEYBOARD HISTORY, DASKEYBOARD, http://www.daskeyboard.com/blog/?page_id=1329 (last visited May 3, 2012) (discussing the transition from typewriters to modern computer keyboards).

372. See *Cathode Ray Tube (CRT) Monitor*, HIST. OF COMPUTERS, <http://history-computer.com/ModernComputer/Basis/cathode.html> (last visited May 3, 2012). Modern computer screens are now generally based on liquid crystal display technology. See *Liquid Crystal Display (LCD)*, HIST. OF COMPUTERS, <http://history-computer.com/ModernComputer/Basis/lcd.html> (last visited May 3, 2012).

373. Courtney Livingston Quale, Note, *Hear an [Expletive], There an [Expletive], But[t] . . . the Federal Communications Commission Will Not Let You Say an [Expletive]*, 45 WILLAMETTE L. REV. 207, 214 (2008).

374. See BURKE, PINBALL EFFECT, *supra* note 10, at 146-47.

375. See Bonnie Cha, *Smartphones Unlocked: Understanding Processors*, CNET (Aug. 8, 2011, 12:00 AM), http://www.cnet.com/8301-17918_1-20088704-85/smartphones-unlocked-understanding-processors/ (describing the various processors used in cell phone technology).

376. See *Smartphone Features*, PC MAG., http://www.pcmag.com/encyclopedia_term/0,1237,t=smartphone+features&i=6433,00.asp (last visited June 21, 2012).

377. See NAT'L RESEARCH COUNCIL, THE GLOBAL POSITIONING SYSTEM: A SHARED NATIONAL ASSET: RECOMMENDATIONS FOR TECHNICAL IMPROVEMENTS AND ENHANCEMENTS 13-14 (3d ed. 1997) (describing the government's role in the creation of GPS systems).

378. *Id.* at 13-14, 16.

that were needed to create the GPS system included those associated with satellites, rockets, radios, radar, semiconductors, solar batteries, computers and atomic clocks.³⁷⁹

III. COMMERCIAL FEASIBILITY

Although the issue has not arisen very often, it would seem that the state-of-the-art concept should include commercial as well as technological feasibility. Some technological innovations achieve immediate commercial success. For example, printing was quickly accepted by literate consumers in fifteenth century Europe. By 1480, printing presses were located in at least 110 towns.³⁸⁰ By 1500, there were more than 35,000 editions and 20 million individual books in print.³⁸¹ Railroads were also an immediate success, both in Great Britain and in the United States.³⁸² For example, in its first full year of operation, the Liverpool & Manchester Railway carried about 445,000 passengers and 43,000 tons of freight.³⁸³ By 1860, railroad companies had laid down nearly 15,000 miles of track in Great Britain and 30,000 miles of track in the United States.³⁸⁴ In more recent times, personal computers and cell phones also achieved commercial success relatively quickly. For example, personal computer sales went from 48,000 in 1977³⁸⁵ to more than 300 million in 2008.³⁸⁶ Mobile telephones were even more successful as cell phone subscribers increased worldwide from 12.4 million in 1990 to more than 4.6 billion in 2010.³⁸⁷

379. See generally *Real-World Relativity: The GPS Navigation System*, OHIO ST. U. (Apr. 27, 2009), <http://www.astronomy.ohio-state.edu/~pogge/Ast162/Unit5/gps.html> (providing background on GPS technology).

380. See BURKE, CONNECTIONS, *supra* note 265, at 105.

381. See BURKE, PINBALL EFFECT, *supra* note 10, at 274. Book sales were boosted by the practice, pioneered by the Venetian printer, Aldus Manutius, of publishing inexpensive octavo-sized editions that could be easily carried in a customer's saddlebag. See *id.*

382. Construction began on the first railroad in America, the Baltimore & Ohio Railroad in 1826. See Susan P. Fino, *A Cure Worse Than the Disease? Taxation and Finance Provisions in State Constitutions*, 34 RUTGERS L.J. 959, 965-67 (2003); Jerry L. Mashaw, *Administration and "The Democracy": Administrative Law from Jackson to Lincoln, 1829-1861*, 117 YALE L.J. 1568, 1570 n.4 (2008).

383. See MCGOWAN, *supra* note 316, at 265.

384. See DERRY & WILLIAMS, *supra* note 1, at 302 (“The length of the railways [in the United States] grew in that time from 10,000 to 30,000 miles, which was more than twice the entire network of the United Kingdom.”).

385. *Disruptive Technology Stocks for Smart Small-Cap Investors*, MONEY MORNING (Apr. 6, 2012), <http://www.moneymorning.com.au/20120406/disruptive-technology-stocks-for-smart-small-cap-investors.html>.

386. See *Worldwide PC Shipments in 2008*, ZDNET (Mar. 16, 2009, 4:56 AM), <http://www.zdnet.com/blog/itfacts/worldwide-pc-shipments-in-2008/15672> (listing total 2008 shipments at 302,207,500).

387. *The Birth of the Mobile Phone*, CISCO COMMUNITIES (Jan. 12, 2012, 10:52 AM),

A. Catalysts to the Commercialization of Technology

There are a number of events or conditions that can create a receptive environment for new products and technologies, including sudden changes in the physical environment, depletion of natural resources, military competition among nations, popular dissatisfaction with the state of existing technology, as well as changing demographic and social conditions. Many of these changes are beyond a manufacturer's control.

1. *Environmental Changes.*—Over the centuries, changes in the physical environment have often provided an economic incentive for the introduction of new products and technologies. For example, in the fourteenth century a drop in temperature caused by the Little Ice Age led to the invention of fireplaces and chimneys to provide better home heating.³⁸⁸ Also, the introduction of knitting and buttons during that period enabled tailors to make warmer clothing.³⁸⁹ In our own century, concern about global warming has generated a potential market for the development of “green” technologies like recycling, solar power, and alternative fuels for cars and trucks.

2. *Depletion of Natural Resources.*—Depletion of natural resources also creates a demand for substitute products. The destruction of English forests in the sixteenth and seventeenth centuries due to glassblowing and shipbuilding activities triggered improvements in coal mining technology when coal replaced wood as a fuel source in many industries.³⁹⁰ In the nineteenth century, the excessive killing of African elephants led to a shortage of natural ivory and thereby created a market for celluloid billiard balls and other ivory substitutes.³⁹¹ In the twenty-first century, the depletion of fossil fuels has encouraged the development of alternative fuel technologies for both transportation and power generation.

3. *Military Competition.*—An arms race can also provide a ready market for new technologies.³⁹² For example, in the mid-nineteenth century, when exploding shells fired by rifled guns took the place of smooth-bore cannons and solid shot, navy officials realized that they needed to replace slow-moving wooden sailing ships with something better.³⁹³ As a result, they were receptive to the introduction of ironclads and iron-hulled steam powered warships once they became available.³⁹⁴ During this same period, European and American armies were also quick to abandon their traditional smoothbore muskets for more

<https://communities.cisco.com/community/solutions/sp/mobility/blog/2012/01/12/the-birth-of-the-mobile-phone>.

388. See BURKE, CONNECTIONS, *supra* note 265, at 157-59.

389. *Id.* at 161.

390. DERRY & WILLIAMS, *supra* note 1, at 145-47.

391. See BURKE, CONNECTIONS, *supra* note 265, at 279.

392. See DERRY & WILLIAMS, *supra* note 1, at 278.

393. See JOHN BEELER, BIRTH OF THE BATTLESHIP 70-71 (2001).

394. See *id.*

rapid firing breech-loading rifles.³⁹⁵ Later, military strategists spotted the potential of airplanes. Within eight years of the Wright brothers' first flight in 1903, the Italian Army employed airplanes to bomb Turkish positions during the Italian-Turkish war.³⁹⁶ In more recent times, radar, rocket, helicopter and jet engine technology developed at an increased pace during World War II.³⁹⁷

4. *Dissatisfaction with Existing Technology.*—Dissatisfaction with existing technology creates opportunities for those who can “build a better mousetrap.”³⁹⁸ As mentioned earlier, printed books were commercially successful because they were much cheaper and much easier to read than hand written codices. Likewise, railroads quickly replaced stage coaches because they were faster, cheaper to operate, safer and more comfortable than horse powered transportation. Railroads also offered a better means of transporting bulk goods than canals and eventually put most of the canal companies out of business. Ocean-going steamships replaced wooden sailing ships for the same reason. Unlike sail powered packet ships, steamships could maintain fixed schedules because they were not dependent on the wind. After the introduction of compound-expansion engines, high-pressure boilers, iron and steel hulls and the screw propeller, steamships became larger, faster and more reliable than sailing ships and almost entirely replaced them by the latter decades of the nineteenth century.

Another example of the triumph of one technology over another involves illumination.³⁹⁹ Originally, homes and factories were illuminated by candles, oil lamps, and later by coal gas. However, once electric lighting appeared on the scene, it displaced these other forms of illumination because it was safer, more convenient to use and provided more illumination. Finally, the gasoline powered automobile not only supplanted the horse and carriage, it also displaced electric and steam powered vehicles, which were more expensive and less convenient than their gasoline powered competitors.⁴⁰⁰

5. *Demographic Changes.*—Demographic changes may also encourage commercial acceptance of new products. For example, in the late fourteenth

395. See BLACK, *supra* note 271, at 111-12.

396. *Id.* at 154.

397. See BLACK, *supra* note 271, at 174-76 (radar); *id.* at 188 (jet fighters); ERNST KLEE & OTTO MERK, *THE BIRTH OF THE MISSILE: THE SECRETS OF PEENEMÜNDE 10-24* (T. Schoeters trans., 1965) (German rockets); J. GORDON LEISHMAN, *PRINCIPLES OF HELICOPTER AERODYNAMICS* 1-49 (2d ed. 2006) (helicopters); *20th Century and Beyond*, NASA, <http://www.grc.nasa.gov/WWW/k-12/rocket/BottleRocket/20thBeyond.htm> (rockets) (last visited June 21, 2012).

398. Ralph Waldo Emerson is generally attributed with saying, “If you build a better mousetrap, the world will beat a path to your door.” Thomas Cooper & Tom Kelleher, *Better Mousetrap? Of Emerson, Ethics, and Postmillennium Persuasion*, 16 J. MASS MEDIA ETHICS 176, 176 (2001).

399. See generally Walter Hough, *The Development of Illumination*, 3 AM. ANTHROPOLOGIST 342 (1901) (providing history of illumination).

400. See William W. Bottorff, *What Was the First Car? A Quick History of the Automobile for Young People*, AUSTIN BUS. COMPUTERS, INC., <http://www.ausbcomp.com/~bbott/cars/carhist.htm> (last visited May 3, 2012).

century, population losses from the Black Death caused wages to increase, thereby creating a demand for linen undergarments (made cheaper by the invention of the horizontal loom and the spinning wheel).⁴⁰¹ Later, in Western Europe, an increase in population during the nineteenth century created a need to produce more food and, thus, stimulated an interest in mechanized farm equipment like steam tractors and reapers.⁴⁰² Increased population also led to greater urbanization, which made it possible to popularize gas lighting and movie theaters.⁴⁰³

6. *Social Changes*.—Finally, changes in social conditions may create a demand for new products and technologies. For example, increases in the literacy rate during the Renaissance fueled a strong demand for inexpensive books just at a point in time when printing by means of movable type was invented.⁴⁰⁴ The expanding number of female drivers contributed to the commercial success of the self-starter for automobiles when it was introduced in 1912.⁴⁰⁵ In more recent times, the phenomenon of the two-earner household has no doubt helped to sustain a ready market for household gadgets.⁴⁰⁶

B. Impediments to Commercial Acceptance of Technology

However, sometimes an otherwise promising technology does not catch on right away. There can be many reasons for this, including high cost, competition from other products or technologies, lack of demand for the product or technology, resistance from special interest groups, cultural resistance or opposition from religious groups, and lack of existing infrastructure support. These conditions are also largely beyond a manufacturer's control.

1. *High Costs*.—In some cases, an innovative product may be too expensive in either absolute or relative terms to achieve commercial success when it is first introduced. A product that is too expensive in absolute terms is one which the public would like to purchase, but cannot afford. For example, when automobiles were built to order, only comparatively wealthy persons could afford them. Eventually, however, mass production techniques were introduced which made automobiles more affordable.⁴⁰⁷ Likewise, prior to World War II, air travel

401. See BURKE, CONNECTIONS, *supra* note 265, at 98-100.

402. See DERRY & WILLIAMS, *supra* note 1, at 70-74.

403. See *id.* at 278.

404. See BURKE, CONNECTIONS, *supra* note 265, at 105-06.

405. See THE AUTOMOBILE AND AMERICAN CULTURE 139 (David L. Lewis & Laurence Goldstein eds., 1983).

406. See Steven Lugauer et al., *The Effect of Household Appliances on Female Labor Force Participation: Evidence from Micro Data*, 17 LABOUR ECON. 503 (2010); Susan Guibert, *Increase in Number of Working Woman Due to Appliance Ownership, Notre Dame Study Shows*, NOTRE DAME NEWS, Jan. 19, 2011, <http://newsinfo.nd.edu/news/18152-increase-in-number-of-working-women-due-to-appliance-ownership-notre-dame-study-shows>.

407. See JULIAN PETTIFER & NIGEL TURNER, AUTOMANIA: MAN AND THE MOTOR CAR 173 (1984).

was very expensive and only the wealthy could afford to fly.⁴⁰⁸ After the War, as passenger planes became larger and faster, flying became cheaper and more popular with the general public.⁴⁰⁹ The same may be occurring today with regard to space travel. Recently, Virgin Galactic has begun to take reservations on its spaceship WhiteKnightTwo for space flights.⁴¹⁰ Unfortunately, the cost is \$200,000 per passenger.⁴¹¹ Although this cost may eventually come down, space travel will probably not become an established means of mass transportation anytime soon.

2. *Competition.*—A product may also encounter resistance in the marketplace because it is more expensive to purchase or operate than its competition. For example, ocean-going steamships did not supersede wooden sailing ships until the middle of the nineteenth century in part because they consumed too much coal in relation to the amount of power that they generated.⁴¹² It was not until compound-expansion engines were installed, along with more efficient boilers, iron and steel hulls, and screw propellers, that oceangoing steamships were able to compete successfully with sailing ships.⁴¹³ A similar problem seems to have stymied the commercialization of electric cars in the twenty-first century. Due to the high cost of rechargeable batteries, it is estimated that an electric automobile costs at least \$5000 more than a comparable gasoline powered vehicle.⁴¹⁴ For this reason, the public has been slow to embrace electric cars although this may change if the price of gasoline increases dramatically.⁴¹⁵

3. *Lack of Demand.*—Lack of demand may also be based on the perception that the product or technology is not needed. For example, carriage owners shunned pneumatic tires in the 1840s, though they readily purchased solid rubber tires, because they felt that the suspension system of existing carriages was adequate to handle bumpy road conditions.⁴¹⁶ It was not until bicycles (which had no suspension systems) came into vogue in the 1880s that the market for

408. See CARL SOLBERG, *CONQUEST OF THE SKIES: A HISTORY OF COMMERCIAL AVIATION IN AMERICA* 221 (1979) (declaring that “[t]he well-to-do flew”).

409. *Id.* at 345 (stating that “[s]tarting around 1948, commercial flying began to turn into the kind of travel that the general public could afford”).

410. See Mark Flores, *Blast Off?—Strict Liability’s Potential Role in the Development of the Commercial Space Market*, 17 RICH. J.L. & TECH. 1, 1-2 (2010).

411. See *id.* at 4.

412. See BEELER, *supra* note 393, at 32.

413. See *id.* at 54-60.

414. Press Release, J.D. Power & Assocs., *Future Global Market Demand for Hybrid and Battery Electric Vehicles May Be Over-Hyped; Wild Card Is China* (Oct. 27, 2010), available at <http://businesscenter.jdpower.com/news/pressrelease.aspx?ID=2010213>.

415. See *id.*

416. See DERRY & WILLIAMS, *supra* note 1, at 529 (“But in the same decade of the 1840’s a patent was taken out for pneumatic rubber tyres [sic] with an outer casing of leather: these ‘aerial wheels,’ as they were called, were tested in Hyde Park and ran successfully for as much as 1,200 miles; they even spread to New York, yet the invention was soon forgotten.”).

pneumatic tires improved.⁴¹⁷

4. *Resistance from Special Interest Groups.*—Commercial competitors and workers have also occasionally blocked the introduction of new technology. For example, in the early nineteenth century, canal companies lobbied hard to prevent the construction of railroad lines.⁴¹⁸ Concern about the effect of new technology on existing labor patterns also may delay the introduction of technology. For instance, the Emperor Vespasian opposed the use of waterwheels in the Roman Empire because he believed that it might cause unemployment.⁴¹⁹ In the eighteenth century, the silk weavers of Lyons rioted for the same reason when the Jacquard loom was introduced.⁴²⁰

5. *Cultural or Religious Opposition.*—Religious or social opposition may delay a new technology or prevent its introduction altogether. For example, during the Middle Ages, the Catholic Church banned (without much success) the use of crossbows and gunpowder.⁴²¹ More recently, religious groups have opposed the use of birth control pills and other contraceptive devices.⁴²² New technology may also clash with social or cultural norms. For example, when automobile manufacturers first introduced automatic transmission, the response from the driving public was not very enthusiastic.⁴²³ Years later, there was considerable reluctance by some demographic groups to use seat belts until laws were passed to make seat belt use mandatory.⁴²⁴ On a smaller scale, for many years, professional baseball players resisted using batting helmets because it conflicted with their macho image.⁴²⁵

6. *Lack of Infrastructure.*—Finally, commercial success may elude a new technology because no infrastructure exists to support it. The electric light bulb

417. *Id.*

418. See David E. Lilienthal & Irwin S. Rosenbaum, *Motor Carrier Regulation by Certificates of Necessity and Convenience*, 36 YALE L.J. 163, 187 n.95 (1926).

419. DERRY & WILLIAMS, *supra* note 1, at 252.

420. See BURKE, CONNECTIONS, *supra* note 265, at 111.

421. See JOHN NORRIS, *ARTILLERY: A HISTORY* 4 (2000).

422. See Susan J. Stabile, *State Attempts to Define Religion: The Ramifications of Applying Mandatory Prescription Contraceptive Coverage Statutes to Religious Employers*, 28 HARV. J.L. & PUB. POL'Y 741, 749-55 (2005); Kate Spota, Comment, *In Good Conscience: The Legal Trend to Include Prescription Contraceptives in Employer Insurance Plans and Catholic Charities' "Conscience Clause" Objection*, 52 CATH. U. L. REV. 1081, 1084-87 (2003).

423. See Preston Taylor, *History of the Automotive Automatic Transmission*, DIABLO TRANSMISSIONS, http://www.diablotransmissions.com/history_automatic_transmission.html (last visited June 21, 2012).

424. See Tina Wescott Cafaro, *You Drink, You Drive, You Lose: Or Do You?*, 42 GONZ. L. REV. 1, 5-6 (2006); Barry L. Huntington, Comment, *Welcome to the Mount Rushmore State! Keep Your Arms and Legs Inside the Vehicle at All Times and Buckle Up . . . Not for Your Safety, but to Protect Your Constitutional Rights*, 47 S.D. L. REV. 99, 101 n.14 (2002) (stating that fewer than fifteen percent of drivers used seat belts when they were first introduced in the 1950s).

425. See ROBERT M. GORMAN & DAVID WEEKS, *DEATH AT THE BALLPARK: A COMPREHENSIVE STUDY OF GAME-RELATED FATALITIES, 1862-2007*, at 10-12 (2009).

was a commercial success because Thomas Edison and others constructed power stations and power lines to supply electricity to their customers.⁴²⁶ Infrastructure also contributed to the success of the gasoline-powered automobile. In contrast to the early nineteenth century, when the pothole covered roads of London thwarted the efforts of Richard Trevithick to introduce steam carriages to Regency England, by the end of that century a macadamized road system existed, at least in urban areas that ensured the success of gasoline-powered automobiles.⁴²⁷ In addition, oil refineries were already in operation making kerosene and lubricating oil when automobiles were first introduced.⁴²⁸ The distillation process being used in these refineries could be readily adapted to manufacture gasoline.⁴²⁹ In contrast, electric cars failed to catch on at the beginning of the twentieth century, at least in part, because of the lack of charging or battery swapping facilities outside of urban areas.⁴³⁰

IV. RETHINKING THE STATE-OF-THE-ART CONCEPT

State-of-the-art is a confusing concept in the law of products liability. Its rationale is indeterminate; its meaning is muddled; and, its procedural effects are highly variable. Accordingly, this portion of the Article will offer some suggestions for clarifying the state-of-the-art concept and defining its proper role in products liability litigation.

A. *Rationale*

The principal function of the state-of-the-art doctrine is to provide a practical limit to the concept of defectiveness and, thereby, limit the scope of strict products liability. Almost fifty years ago, the drafters of section 402A declared that liability would only be imposed on sellers for injuries that were caused by *defective* products.⁴³¹ This defectiveness requirement has also been retained by the *Products Liability Restatement*.⁴³² For this reason, a manufacturer should not be held liable simply because the plaintiff has proposed a safer alternative design. Instead the state-of-the-art concept requires the plaintiff to prove that it was actually possible for the manufacturer to have adopted the proposed design when the product was sold.⁴³³ This same principle supports a requirement that any

426. See DERRY & WILLIAMS, *supra* note 1, at 615-21.

427. This new process for paving roads was developed by James McAdam in the 1820s and 1830s. *Id.* at 432-36.

428. See BURKE, CONNECTIONS, *supra* note 265, at 180.

429. See *id.*

430. See Robert Bryce, *Five Myths About Green Energy*, WASH. POST, Apr. 25, 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/04/23/AR2010042302220.html> (discussing unreliability of electric car batteries).

431. See OWEN, *supra* note 11, § 6.1, at 343.

432. See RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2 (1998).

433. See *id.*

alternative design submitted by a plaintiff be commercially feasible.⁴³⁴ A requirement that plaintiffs show that their proposed alternative designs are commercially feasible helps to ensure that manufacturers are not punished for making efficient design decisions.

B. Terminology

At the present time, the term *state-of-the-art* has no fixed meaning in products liability law. To some courts, it refers to customs or practices of the industry.⁴³⁵ Other courts take a broader view and include safety standards promulgated by trade associations, independent standards development organizations, or government regulatory agencies within the *state-of-the-art* concept.⁴³⁶ A third alternative defines *state-of-the-art* as that which is technologically feasible.⁴³⁷ Finally, a few courts have included commercial feasibility within the definition of *state-of-the-art*.⁴³⁸

Considering that there is no consensus about the meaning of *state-of-the-art*, it might be better to avoid the phrase entirely and rely instead on terms like “technological feasibility” and “commercial feasibility,” which have more generally accepted meanings. Under this approach, technological feasibility would include: (1) knowledge of the underlying scientific principles; (2) the ability to convert these scientific principles into working models and prototypes of the product or safety device in question; and (3) the capacity to manufacture the product or safety device on a commercial scale.⁴³⁹ In some cases, technological feasibility would also include the ability to purchase necessary raw materials or component parts from other vendors. Commercial feasibility, on the other hand, means that: (1) there is an existing or potential consumer interest in the product or safety device; (2) the manufacturer has the resources to market and distribute the product or safety device to the public; and (3) the technology has developed to the point where the product or safety device can be offered for sale at an affordable price.⁴⁴⁰

C. The Procedural Effect of State-of-the-Art Evidence in Product Liability Litigation

Until recently, defendants often relied on *state-of-the-art* evidence to establish that their product designs were not defective.⁴⁴¹ However, requiring a

434. *See id.*

435. *See id.*

436. *See* discussion *supra* Part I.B.1.

437. *See* OWEN, *supra* note 11, § 10.4, at 710-11.

438. *See, e.g.,* Boatland of Hous., Inc. v. Bailey, 609 S.W.2d 743, 746 (Tex. 1980).

439. OWEN, *supra* note 11, § 10.4, at 711-12.

440. *Id.*

441. *See* O'Brien v. Muskin Corp., 463 A.2d 298, 305 (N.J. 1983), *superseded by statute as stated in* Dewey v. R.J. Reynolds Tobacco Co., 577 A.2d 1239 (N.J. 1990); Crispin v. Volkswagenwerk AG, 591 A.2d 966, 973 (N.J. Super. Ct. App. Div. 1991); Patterson v. Ravens-

manufacturer to prove that its product conforms to the state-of-the-art is the wrong approach. On one hand, if conformity with state-of-the-art is equivalent to feasibility, then any product that was produced and sold commercially would be “feasible” and, therefore, would conform to the state-of-the-art. Such a test would be meaningless. On the other hand, if conformity with the state-of-the-art requirement meant that the defendant’s design had to reflect the highest level of technology available, many products would fail to meet this standard. However, this standard seems wrong because a product’s design does not have to be the best or the safest; it simply has to be non-defective.⁴⁴²

The *Product Liability Restatement*’s approach is more logical. Section 2(b) of the *Products Liability Restatement* requires the plaintiff to prove that a product is defectively designed by showing that a reasonable alternative design would have prevented or reduced his or her injuries.⁴⁴³ Arguably, for a design to be “reasonable,” it must be technologically and commercially feasible.⁴⁴⁴ Of course, once the plaintiff offers proof by expert testimony that his or her proposed alternative design was technologically and commercially feasible at the time of sale, the defendant will then need to rebut this claim with evidence that the plaintiff’s proposed design was not in fact technologically or commercially feasible at that time.⁴⁴⁵

How does a defendant go about rebutting the plaintiff’s claim that a proposed alternative design is technologically and commercially feasible? This will be difficult to do if some or all of the defendant’s competitors have already adopted the plaintiff’s alternative design at the time of sale. However, if the alternative design was not in use at the time of sale by the defendant, but some or all of the defendant’s competitors have adopted it since then, the defendant would have little choice but to argue that the design was not technologically feasible at the time of sale.⁴⁴⁶ If the alternative design had not been adopted by any of the

Metal Prods., Inc., 594 N.E.2d 153, 161-62 (Ohio Ct. App. 1991); Owens-Corning Fiberglass Corp. v. District Court (*Caldwell*), 818 S.W.2d 749, 752 (Tex. 1991).

442. See *Davis v. Caterpillar Tractor Co.*, 719 P.2d 324, 326-27 (Colo. App. 1985) (holding that tractor was not defective because it was not equipped with rollover protective device even though such devices were available).

443. See RESTATEMENT (THIRD) OF TORTS: PROD. LIAB. § 2(b) (1998).

444. See OWEN, *supra* note 11, § 10.4, at 737.

445. See *Rucker v. Norfolk & W. Ry. Co.*, 381 N.E.2d 715, 725 (Ill. App. Ct. 1978), *rev’d on other grounds*, 396 N.E.2d 534 (Ill. 1979).

446. See *Bruce v. Martin-Marietta Corp.*, 544 F.2d 442, 446-47 (10th Cir. 1976) (rebutting evidence that passenger planes were equipped with better seats when accident occurred in 1970 by arguing that these seats were not in use when the airplane was manufactured in 1952); *Brady v. Melody Homes Mfr.*, 589 P.2d 896, 898 (Ariz. Ct. App. 1978) (responding to evidence that mobile homes were currently equipped with smoke detectors and pop-out windows by pointing out that no manufacturer provided these safety features ten years earlier when the mobile home in question was manufactured); *Wiska v. St. Stanislaus Social Club, Inc.*, 390 N.E.2d 1133, 1137 (Mass. App. Ct. 1979) (excluding evidence of safer windshield glass that was adopted by the automobile industry two years after the accident).

defendant's competitors, but had been adopted by other industries at the time of sale; the defendant would likely contend that it was not possible to transfer the technology from one industry to another.⁴⁴⁷ Finally, if the plaintiff's alternative design is purely hypothetical and has not been adopted by anyone, either at the time of sale or the time of trial, the defendant would likely argue that the proposed design either was not commercially feasible, but like Leonardo's helicopters, would have to await additional developments before it would become technologically feasible.⁴⁴⁸

D. A Statutory Approach

Assuming that these observations have merit, what is the best mechanism for changing the existing state-of-the-art doctrine? The best approach would probably be to codify this version of the state-of-the-art doctrine by statute. A number of states have already adopted statutes that purport to protect products sellers from liability when their products have been designed in accordance with the prevailing state technological development in the industry at the time of sale.⁴⁴⁹ Some of these statutes require that the defendant be able to conform to the state-of-the-art or they make conformance to the state-of-the-art an affirmative defense.⁴⁵⁰ Others provide that products that conform to the state-of-the-art are presumed to be non-defective.⁴⁵¹ Finally, a few statutes have adopted the *Product Liability Restatement's* approach and require the plaintiff to offer proof of a feasible alternative design.⁴⁵²

I believe that any statutory codification of the state-of-the-art doctrine should

447. See *Boatland of Hous., Inc. v. Bailey*, 609 S.W.2d 743, 747 (Tex. 1980) (concluding that evidence of use of kill switches in racing boats did not necessarily prove that such devices were within the state-of-the-art for bass boats). But see *Hillrichs v. Avco Corp.*, 514 N.W.2d 94, 97 (Iowa 1994) (allowing plaintiff whose hand was caught in rollers of corn husking machine to present evidence that manufacturers of printing presses equipped their machines with emergency stop devices).

448. See, e.g., *Stanczyk v. Black & Decker, Inc.*, 836 F. Supp. 565, 566-68 (N.D. Ill. 1993) (excusing proposed safer design that had not been tested for feasibility); *Maxted v. Pac. Car & Foundry Co.*, 527 P.2d 832, 834 (Wyo. 1974) (refusing to allow as evidence drawings and model of a safety device for tractor-trailers that had never been tested or constructed at the time of manufacture).

449. See OWEN, *supra* note 11, § 10.4, at 734-36.

450. ARIZ. REV. STAT. § 12-683 (2012); IOWA CODE ANN. § 668.12 (West 2012); LA. REV. STAT. ANN. § 9:2800.59 (2012); MICH. COMP. LAWS ANN. § 600.2948(3) (West 2012); MISS. CODE ANN. §§ 11-1-63(b) to (c) (West 2011); MO. ANN. STAT. § 537.764 (2012); NEB. REV. STAT. § 25-21,182 (2011); N.H. REV. STAT. ANN. § 507:8-g (2011).

451. COLO. REV. STAT. ANN. § 13-21-403(1) (West 2012); IND. CODE § 34-20-5-1 (2011); KY. REV. STAT. ANN. § 411.310(2) (West 2011).

452. LA. REV. STAT. ANN. § 9:2800.56; MISS. CODE ANN. § 11-1-63; N.J. STAT. ANN. § 2A:58c-3 (West 2012); N.C. GEN. STAT. 99B-6 (West 2011); TEX. CIV. PRAC. & REM. CODE ANN. § 82.005 (West 2011); WASH. REV. CODE ANN. § 7.72.030 (West 2012).

contain the following provisions. First, the statute should make it clear that a state-of-the-art analysis should only be applied to evaluate a safer alternative design proposed by the plaintiff. Second, although the plaintiff's proposed alternative design does not have to be actually adopted by others in the industry, the plaintiff must prove that the proposed alternative design was technologically and commercially feasible at the time of sale. Third, the defendant is allowed to rebut the plaintiff's evidence by offering evidence that the proposed alternative design was not technologically or commercially feasible at the time the product was sold. Fourth, the defendant should be allowed to prove that the plaintiff's proposed alternative design was not technologically feasible by alleging that it could not control its development. If the plaintiff fails to prove that his or her proposed alternative design is technologically and commercially feasible, the case against the defendant must be dismissed. On the other hand, even if the plaintiff proves that his or her proposed design is technologically and commercially feasible, the defendant should still be able to avoid liability by showing that its existing design is not defective because it is more aesthetically pleasing or offers more convenience or consumer choice.

CONCLUSION

It seems inherently unfair to hold a manufacturer liable for failing to do something that is beyond the scope of existing technology. At the same time, it is desirable to have a liability rule that encourages producers to make optimal investments in product safety. The state-of-the-art concept is one device to induce manufacturers to achieve what is technologically and commercially possible in the area of product safety. However, some courts and statutes incorrectly focus on the technological and commercial feasibility of the manufacturer's design choices instead of looking at the feasibility of alternative designs. Ideally, the plaintiff should be required to prove that the defendant's product is defectively designed by offering evidence of a safer alternative design. The defendant should then be allowed to show that the proposed design was not capable of being produced and marketed using the technology that was available at the time.⁴⁵³

Furthermore, the defendant should be permitted to show that the technology behind the plaintiff's proposed design is interdependent in nature and, therefore, not solely within the defendant's control. In the event a safer design was technologically feasible at the time the product was sold, the manufacturer should be allowed to argue that the design was not commercially feasible at that time. Finally, even if the plaintiff proves that his or her proposed design is technologically and commercially feasible, the defendant should still be able to show that its design is cheaper, more convenient, or offers a greater range of consumer choice.

453. See *Flock v. Scripto-Tokai Corp.*, 319 F.3d 231, 239 (5th Cir. 2003); *Potter v. Chi. Pneumatic Tool Co.*, 694 A.2d 1319, 1346-47 (Conn. 1997).