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Reasonably Foreseeable Use

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ABSTRACT

All technologists design products for an expected use; this use is the goal of the designer. Clearly, the actual use of products by their community of users is broader than the expected use; indeed, the original use contemplated by the designer may be expanded by marketers before the first prototype is finished. Tort law mandates that products be safely designed for their reasonably foreseeable use which includes not only their expected and expanded uses but also their reasonably foreseeable misuses. The concept of reasonably foreseeable use has a literal meaning in technology and this paper explores its impact as a design constraint.

INTRODUCTION

A tort is a private or civil wrong or injury for which the court will provide a remedy in the form of an action or damages. Product liability is a tort which makes a manufacturer liable if its product has a defective condition that makes it unreasonably dangerous to the user or consumer. Historically, product liability actions were usually grounded on two legal theories known as Warranty and Negligence. Under these concepts, litigation reached an equilibrium state that was shattered in 1965 when a new theory was introduced known as Strict Liability [Restatement, Second, Torts § 402 A]. Strict liability opened up litigation floodgates by allowing, for the first time, injured parties to recover who did not have "clean hands" (contributory negligence) and who were not purchasers of the product (privity), e.g., users or bystanders. Despite its radical impact on the legal community, strict liability had almost no effect on engineering principles as expressed in the first canon of ethics. We observe that both doctrines have the same aim and sweep:

Strict Liability - Restatement, Second, Torts § 402A

(1) One who sells any product in a defective condition unreasonably dangerous to the user or consumer or to his property is subject to liability for physical harm thereby caused to the ultimate user or consumer, or to his property, if

(a) the seller is engaged in the business of selling such a product, and

(b) it is expected to and does reach the user or consumer without substantial change in the condition in which it is sold.

(2) The rule stated in Subsection (1) applies although

(a) the seller has exercised all possible care in the preparation and sale of his product, and

(b) the user or consumer has not bought the product from or entered into any contractual relation with the seller.

First Canon of Engineering Ethics

Engineers, in the fulfillment of their professional duties, shall hold paramount the safety, health and welfare of the public.

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No Charge

On the other hand, a common law concept known as reasonably foreseeable use has dramatically altered product design. The following statutes and decisions show how the concept has been integrated into the law. Taken together, they define the expectations of the judicial value system.

Illinois:

The manufacturer of a product owes a duty to design the product so that it is reasonably safe for its intended use and for any reasonably foreseeable use [Johnson v. Amerco, Inc. (1980), 87 Ill. App. 3d 827, 409 N.E. 2d 299; Murphy v. Cory Pump & Supply Co. (1964), 47 Ill. App. 2d 382, 197 N.E. 2d 849] and is liable in tort for the negligent design of a product that imposes an unreasonable risk of harm upon the user [see Mieher v. Brown (1973), 54 Ill. 2d 539, 301 N.E. 2d 307].

The conduct of the operator of machinery is a defense to a product liability action only where it is shown that such conduct amounted to a misuse of the product [Williams v. Brown Manufacturing Co. (1970), 45 Ill. 2d 418, 425]. The causal connection between an allegedly defective product and the injury is broken only where the misuse was not reasonably foreseeable. [Lewis v. Stran Steel Corp. (1974), 57 Ill. 2d 94, 102, 311 N.E. 2d 128].

Michigan:

The court held that a merchant seller warrants that his goods are "fit for the ordinary purposes for which such goods are used." The "ordinary purposes" contemplated by M.G.L. c.106, §2-314(2)(c) include both those uses which the manufacturer intended and those which are reasonably foreseeable.

The court further held that a defendant manufacturer is not liable for the consequence of the unforeseeable misuse of a product and that warranty liability is not absolute liability. The manufacturer of a motor vehicle is not obliged to make its product collision-proof. In making its design decisions, the manufacturer has a duty to design its product so as to eliminate any unreasonable risk of foreseeable injury by a user. [Owens v. Allis-Chalmers Corporation, 414Mich413, 425; 326 NW2d 372 (1982)]. A product is "unreasonably dangerous" if it creates unreasonable risk of foreseeable injury. [Dooms v. Stewart Bolling & Company, 68 MichApp 5, 14; 241 NW2d 738 (1976), lv den 397 Mich 862 (1976)].

Montana:

The proper test of a defective product is whether the product was unreasonably unsuitable for its intended or foreseeable purpose. If a product fails this test, it will be deemed defective. (748 P. 2d 917 and 918.)

New Mexico:

A "defect" may arise from design, manufacturing, or packaging flaws, or from the warnings in directions which accompany the product. A manufacturer will be liable for harm caused by a product that is unreasonably dangerous due to its condition or manner in which it is used, if that use is reasonably foreseeable. (S.C.R.A. 1986 U.J.I. Civ. 13-1402, -1403, -1406.) If a product is unreasonably dangerous, it is necessarily defective. An unreasonable risk of injury is a risk which a reasonably prudent person having no knowledge of the risk would find unacceptable. (S.C.R.A. 1986 U.J.I. Civ. 13-1407.)

Maine:

Maine's Strict Liability Statute, 14 M.R.S.A. §221, imposes liability on manufacturers and suppliers who market defective, unreasonably dangerous products. The seller becomes subject to liability if an unreasonably dangerous product causes injury to a foreseeable consumer or user. The product must, however, be in some respect defective before liability will be imposed. See generally Austin v. Raybestos Manhattan, Inc., 471 A.2d 280, 28283 (Me. 1984), Bernier v. Raymark Industries, Inc., 516 A.2d 534 (Me. 1986).

When the strict liability defect is a failure to warn, the reasonableness of the manufacturer's conduct is a factor in determining whether the manufacturer had a duty to warn. "The conduct should be measured by knowledge at the time the manufacturer distributed the product. Given the scientific, technological and other information available when the product was distributed, did the manufacturer know or should he have known of the danger. In other words, did he have actual or constructive knowledge of the danger. A product related danger may be regarded as knowable if the available scientific data gave rise to a reasonable inference that the danger is likely to exist." See Bernier v. Raymark Industries, Inc., 516 A.2d 534 (Me. 1986).

Ohio:

Design defect claims are governed by Ohio Rev. Code §2307.75, which provides in pertinent part:

A product is defective in design or formulation if either of the following applies:

1. *When it left the control of its manufacturer, the foreseeable risks associated with its design or formulation as determined pursuant to division (B) of this section exceeded the benefits associated with that design or formulation as determined pursuant to division (C) of this section;*
2. *It is more dangerous than an ordinary consumer would expect when used in an intended or reasonably foreseeable manner.*

(B) The foreseeable risks associated with the design or formulation of a product shall be determined by considering factors including, but not limited to, the following:

1. *The nature and magnitude of the risks of harm associated with that design or formulation in light of the intended and reasonably foreseeable uses, modifications or alterations of the product;*
2. *The likely awareness of product users, whether based on warnings, general knowledge, or otherwise, of those risks of harm;*
3. *The likelihood that that design or formulation would cause harm in light of the intended and reasonably foreseeable uses, modifications or alterations of the product;*

4. *The extent to which that design or formulation conformed to any applicable public or private product standard that was in effect when the product left the control of its manufacturer.*

(C) The benefits associated with the design or formulation of a product shall be determined by considering factors including, but not limited to, the following:

1. *The intended or actual utility of the product, including any performance or safety advantages associated with that design or formulation;*
2. *The technical and economic feasibility, when the product left the control of its manufacturer, of using an alternative design or formulation;*
3. *The nature and magnitude of any foreseeable risks associated with such an alternative design or formulation.*

The preceding excerpts give rise to the following conclusions or observations:

1. Reasonable use, purpose, or manner are equivalent expressions.
2. Reasonably foreseeable use includes intended uses and reasonably foreseeable misuses.
3. The economic welfare of the public is always compromised by causing every product to be safely designed for rare misuses. This is similar to asking every financially responsible driver to pay extra premiums for uninsured motorists.
4. The phrases *risk of harm* and *risk of injury* use the term "risk" as probability, chance, or frequency. The phrase *foreseeable risk* adopts a second definition of the term "risk"; a combination of injury severity and injury frequency (here, "risk" is the same as danger).
5. Absolute safety is not a criterion.
6. The phrase magnitude of any foreseeable risk implies that foreseeable entities have a magnitude. It follows that reasonable foreseeability has a magnitude that is not excessive.

The duties of manufacturers and the definitions of safety defects are intimately tied to the concept of foreseeability. This paper formulates foreseeability as a technical concept and studies its assumptions and misconceptions.

TRUE FORESEEABILITY

To foresee is to see beforehand or know in advance, to foreknow, divine or anticipate, in short, to predict the future. It implies supernatural assistance, as through revelation. Foreseeability in the literal sense is impossible given our present state of knowledge. Surely included in the stumbling blocks which prevent true forecasting are the problems of chaos, the unforeseen and inference.

Chaos is the inherent unpredictability in the behavior of a natural system such as atmosphere. It is a state of things in which chance is supreme. It is a daunting challenge just to formulate the underpinnings of chaos theory; forecasting the behavior of chaotic systems is presently inconceivable.

The influence of the unforeseen poses an even more vexing problem in forecasting than chaos which, after all, is still rooted in underlying principles. The unforeseen may intervene and override our ability to foresee, e.g., a virus could cause total worldwide blindness and invalidate all predictions on the effectiveness of warning labels.

Inference is the act of deriving knowledge by reasoning which involves either deductive or inductive methods. It is the forming of a conclusion from data or premises, reasoning from something known or assumed to something else which follows from it. Ultimately, inference is based on our historical understanding of natural phenomena and it involves our implicit faith that known physical relationships will not change in the future; indeed, in the next five seconds. We observe, for example, that our notions of possible and impossible are projections about the future which may fail decisively if nature proves fickle.

<u>Conclusion 1:</u>	**No event is literally foreseeable.**
<u>Conclusion 2:</u>	**Nothing is literally possible or impossible.**

PERSISTENCY OF NATURE

It is an assumption of great moment that the scientific principles and relationships of the past will persist into the future. Setting aside the literal definition of foreseeability, we must perforce accept historical constancy to achieve any workable definition of this term. The assumption is called "The Principle of the Uniformity of Nature." It is widely adopted in Tort Law under the notion, for example, Reasonable Technical Certainty.

<u>Principle of the Uniformity of Nature</u>

It is an article of faith that the laws and relationships in nature will not become invalid in the future leaving us bereft of all our predictive capability. This faith has been expressed as the "Principle of the Uniformity of Nature." The principle is usually expressed as "the future will resemble the past" provided the circumstances for its happening are similar. Furthermore, it will always happen when the same circumstances recur. What justifies the assumption that nature always behaves in the same way under the same conditions? This remains an unanswered question; the uniformity of nature is simply accepted as a postulate, i.e., as a principle that is neither self-evident nor provable, but nevertheless practically necessary and confirmed by all relevant experience. All science rests on this principle*.

* *Kortulak, Ronald, Chicago Tribune science writer, "Falling Up", Mar. 8, 1998 (Perspective): Mr. Kortulak reports, "Now, the new evidence from the Hubble Space Telescope and the largest land-based instruments suggests that the expansion of the universe is picking up speed, a notion that could profoundly affect the universe's future in ways that had not been imagined." He quoted Alan Guth, M.I.T. physicist, "In cosmology, it's not only possible, it's a part of everybody's standard theory that the space between distance can and does increase at rates much faster than the speed of light." He also quoted Craig Hogan, University of Washington (Seattle), theoretical cosmologist, "On large scales, the gravitational force is repulsive and not attractive, and that basically tells us about a new state of matter. That's astonishing and very important."*

Reasonable Technical Certainty

The judicial system regularly asks technologists to opine on foreseeability issues based on a reasonable degree of technical certainty, e.g., a reasonable degree of engineering or scientific or medical certainty. These opinions are always grounded on the Principle of the Uniformity of Nature, and they, of course, never account for unforeseeable influences. Consequently, the legal system never asks for nor requires true foreseeability; it asks for deductive and inductive inferences based on explicit or implicit historical observations. Although these inferences may be incorrect, they are the only predictions technology can provide and they are considered by the judicial value system to form a reasonable basis for forecasting events that have judicial impact.

Conclusion 3: **What Is Past Is Prologue.**[1]

FORESEEABILITY - A WORKABLE DEFINITION

Black's Law Dictionary defines foreseeable as that which is objectively reasonable to expect, not merely what might conceivably occur.[2] This definition is fraught with conundrums, eg.:

- Is it *reasonable* to expect given that the future cannot be predicted?
- How would this definition extend to the term reasonably foreseeable?
- What protocol is provided for determining foreseeable use?
- Isn't the word "objectively" more difficult to define than "foreseeable" itself?

The following alternative definition of foreseeable use is proposed:

Definition: **Foreseeable is that which is predicted solely on the basis of inference.**

This definition does not pretend that reality can be forecast. It does not consider fortuitous events, chaos, the unforeseen and the unknown. Furthermore, it does not assume the persistency of nature. Instead, it focuses on the techniques of deductive and inductive inference which make up the whole of scientific knowledge. Past experience suggests no forecasting methodology superior to inference. All current rational applications of the foreseeability concept reflect this proposed definition of foreseeable.

DEDUCTIVE INFERENCE

Deduction is reasoning from a general truth to a particular instance of the truth. In the more general sense, deduction is any process of reasoning by which one draws conclusions from principles or information already known. A valid deductive argument is one where the truth of its premises guarantees the truth of its conclusion; in some sense the conclusion is already contained in the premises. Consider the following example of deductive inference: "All dogs are mortal. Sherman is a dog. Therefore, Sherman is mortal."

Cause and Effect

Engineering principles are usually relationships between generalized loading and generalized response. For example, Newton's Laws predict the motion of bodies subject to known forces, eg. the trajectory of a bullet; the centrifugal forces acting on a driver during a turn. Human factors relationships may predict the effect of task overloading on human error. Extreme value statistics and structural analysis may be used to relate the "100 year" storm loading to the survivability of a silo roof. The head injury criterion (HIC number) relates the acceleration exposure from head impact to the probability of irreversible brain damage. Analysis methods such as these are used to determine whether systems meet safety codes and standards; they are used to predict and display failure profiles; they are used to establish service life and they are used to determine load ratings based on acceptable failure rates.

Other disciplines are equally involved in deductive inference through the use of valid "cause and effect" relationships. In contrast, it is comic to watch pundits wax eloquent about the future behavior of the stock market.

The Impossible

One of the most provocative applications of deductive inference is to establish impossibility. Water running uphill under ordinary conditions is a violation of the law of conservation of energy. Less cosmic is the impossibility of a chain separating without breaking a link since two solid bodies cannot occupy the same space simultaneously. No form of matter can move faster than the speed of light. Less known examples outside of the technical community fall under the general heading of upper bound theorems. For example, without knowing the actual strength of a ductile structure, one can assert that it cannot exceed a certain bound.

As a final note, things may be impossible that cannot be demonstrated to be so — such is our current state of ignorance.

Conclusion 4: **All inferences based on deduction are foreseeable.**

INDUCTIVE INFERENCE

While engineers and other applied scientists have a particular appreciation for the elegance of deducing specific truths from general truths and would like to think that this type of thinking is human nature, the fact is that most human information processing time is spent doing the opposite; deriving general truths from specific instances based on our experience, intuition and sometimes faith.

The method by which a general law is inferred from observed particular instances is called induction or inductive reasoning. It is a form of nondeductive inference in which the conclusion expresses something that goes beyond what is said in the premise; the conclusion does not follow with logical necessity from the premise. As an example, we can infer the general law that "All crows are black," based on observing a very large number of black crows and not seeing any other color. On the other hand, since all crows have not been observed, can we logically claim to have proved our inference?

Arguments based on induction do not appear to have the rigor nor persuasiveness of deductions which are regarded as rationally grounded. Ultimately, however, the premises in deductive arguments rest on induction from observed cases.

Deterministic Behavior

To develop the notion of making predictions using inductive inference, we shall consider the specific example of forecasting the tensile strength of a strap. If a large number of strap samples are tested in a laboratory and their measured strength values vary only slightly from test to test, the behavior may be treated as deterministic and the strength of a prototype may be taken (predicted) as the laboratory strength. For example, a series of sample straps made from steel cables (wire rope) showed tensile strengths in tons of 21.1, 21.3, 20.9, 21.0, 21.2, 21.3 and 20.8. Here, engineers would characterize the strap strength as 21 tons and they would adopt a safety factor (factor of ignorance) of five. The prediction mechanism is illustrated symbolically in Figure 1a.

Figure 1a could be used to represent the repeated observations of black crows giving rise to the prediction that all crows are black. It also reflects our general experience that children withdraw their hands after touching a hot stove. This, of course, leads to the deterministic prediction of withdrawal response which, nevertheless, may be incorrect for children who are without feeling in their hands. This latter case illustrates how rules of thumb are formulated.[3]

Statistical Inference

Let us reconsider the problem of predicting the strength of a prototype strap where cotton fibers are now used instead of wire rope. We observe that laboratory tests on a sample of cotton straps give the following tensile strengths in pounds: 3.1, 17.2, 119.4, 7.1, 0.5, 22.4, 73.6, 122.8, 11.3, and 53.7. What useful prediction can we now make about the strength of a single prototype? Clearly, nothing can be said.

When no useful one-to-one correspondence can be established between a sample and a prototype, it is reasonable to ask if there is not some relationship between a group of samples and a group of prototypes. In fact, the entire foundation of statistics depends on the existence of just such a relationship. One would hope, for example, that the average strength of a sample group would be reproduced in subsequent groups of specimens. To be really useful, it would be desirable to predict the entire distribution of strengths in subsequent groups of tests, i.e., get the familiar bell-shaped curve for strength v. probability density. This point of view is depicted in Figures 1a and 1b which contrast the deterministic problem with the statistical.

Statistical experiments or observations, such as the strength tests on the straps, yield samples from which we wish to draw conclusions about the corresponding population, which in our example would be the entire universe of cotton straps.

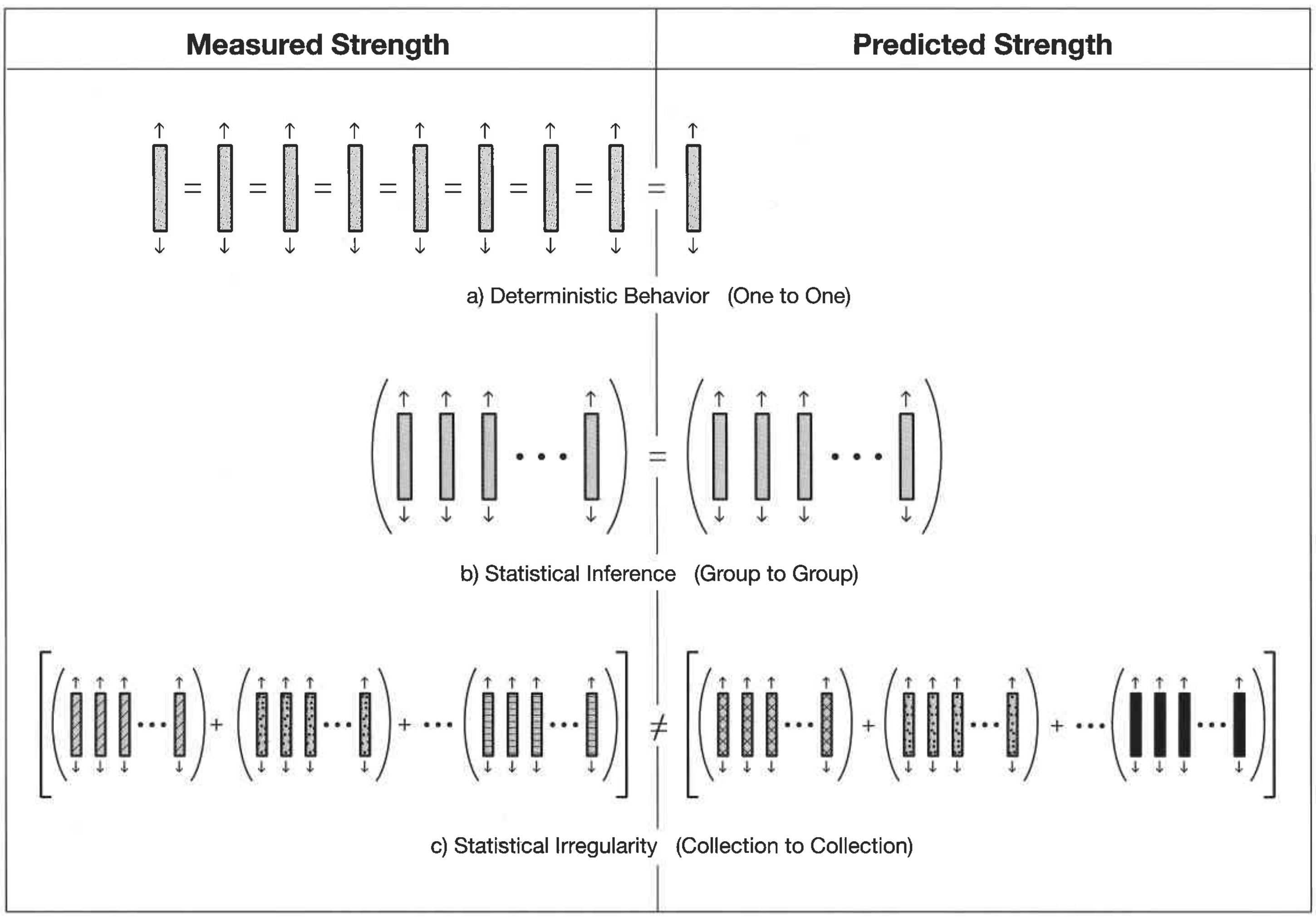


Figure 1

From a safety point of view, it would be useful to know how far a person can reach through a one-inch slot, or how many disabling accidents will occur in a fleet of cranes every one million man-hours of exposure, or what percentage of people can lift a fifty-pound box up to their waists without injury, or how often we may expect an earthquake in Los Angeles to register over eight (8) on the Richter scale?

Statistical inferences or forecasts cannot be made in these examples if a population does not exist, i.e., if there is no relationship between our observations and the future samples. For example, one would expect a pattern to reveal itself if adult Japanese males were measured reaching through a one-inch slot with their dominant hand. Would one expect to see a pattern in arbitrary collections of adult males and females, children of all ages, and candidates chosen from fifteen countries? No such population can be established; each sample chosen in this manner, no matter how large, would be different. Indeed, one property of an infinite population is that every infinite sample (subset) is statistically identical; they have the same average, the same 10 percentile value, the same standard deviation, etc.

Statistical Regularity

It is simply not possible to overemphasize the importance of having a population from which real or imagined samples can be drawn to predict the behavior of future samples. When this is possible, statisticians say the experiments show "statistical regularity", i.e., all bell-shaped curves for the various samples are nearly identical. To illustrate statistical regularity, consider an experiment by K. Pearson who caused a coin to be tossed 24,000 times; he obtained 12,012 heads for a relative frequency of 0.5005 (almost the theoretical value 1/2). Later, Buffon performed a flipping experiment using a sample of 4040 coins. Based on the first tests we would predict 2022 heads (0.5005 x 4040); he actually obtained 2048 heads. Taking the first 12,000 tests of K. Pearson as a subset, we would predict 6006 heads (0.5005 x 12,000); the actual number was 6019. All these tests are summarized in Table I.

Turning once again to the problem of forecasting the strength of straps, we shall now consider the behavior of ceramic straps. For ceramic materials we often encounter an impoverished capability for manufacturing a consistent material reflecting the same strength population from batch to batch. This situation is illustrated in Figure 1c where the measured strength is derived from a mixture of different materials which nevertheless have the same chemical composition and superficial appearance. Unfortunately, the predicted sample is a different mixture of materials; it contains new ingredients and different proportions of the old ingredients. Nothing can be forecast in this case.

As another example of the statistical irregularity illustrated in Figure 1c, consider a fleet of identical model cranes that have the following one year accident profile: two power line contacts, one tipover, one two-blocking incident, one fall from the crane roof, an ingress accident, two runovers, and one dropped load. These nine accidents, when divided by the number of million man-hours of exposure, give the accident frequency rate (AFR) for the cranes, i.e., the number of disabling accidents per million man-hours. Would one expect the same mix of

Table I – Coin Tossing Relative Frequency Experiments

Experiments by	Number of Throws	Number of Heads	Relative Frequency of Heads
K. Pearson	24,000	12,012	0.5005
Buffon	4040	2048	0.5069
K. Pearson	12,000	6019	0.5016

crane accidents in the following year or ever again? If not, one cannot predict the AFR for any forthcoming year. Applying these ideas to the area of machinery, we obtain the AFR bar graphs show in Figure 2.[4] Clearly, the AFR for machinery never settles down, making its prediction impossible.

On the other hand, the bar graphs shown in Figure 3 for automobile collisions with other vehicles[5] depict very few serious migrations. Here, forecasting is possible because we fit the model of Figure 1b where statistical regularity reigns.

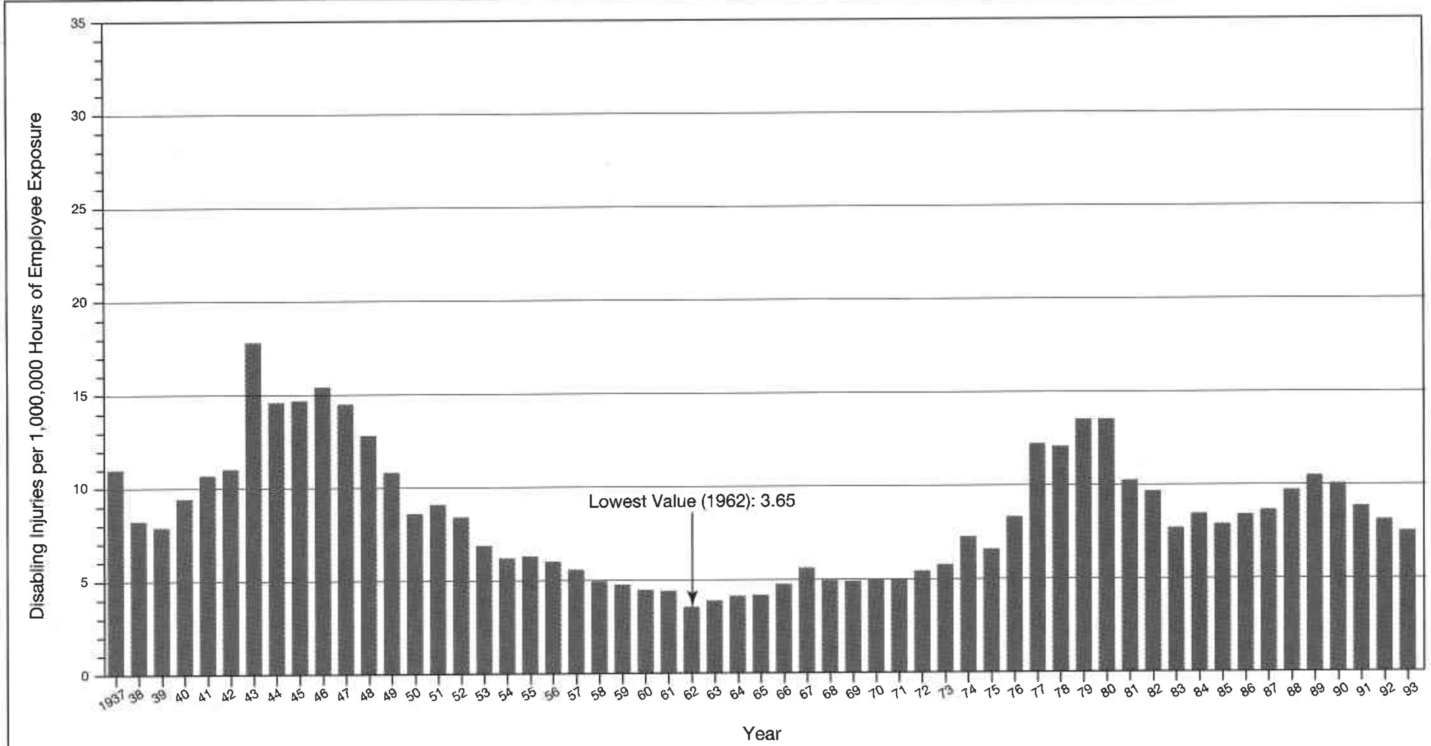
<u>Conclusion 5:</u> **The vast edifice of our beliefs about the natural world rests on premises reached by inductive inference.**

<u>Conclusion 6:</u> **If there is no measured or predicted pattern of behavior, no statistical inference is possible and the behavior is unforeseeable.**

2. Possible/Foreseeable/Zero Probability

Possible events are those not prohibited by known relationships. For example, white crows are not possible; if they were, it would violate the inductive inference "all crows are black." On the other hand, although there is no recorded single human birth of 11 offspring, no known reasons exist why this could not occur. The 1997 Guinness Book of World Records indicates that 10 is the highest recorded single birth; Spain in 1924, China in 1936, and Brazil in 1987.

Obviously, impossible events are not foreseeable; inductive inference cannot forecast their existence. Further, when there is a zero probability that a possible event will materialize, this too is not foreseeable by definition. We finally arrive at a more subtle concept. Is an event possible when its probability of occurrence is zero? The answer is Yes. To make this clear to non-statisticians, we begin with the notion that probability is an *idealization* of the proportion of times that a certain result will occur in repeated trials of an experiment. As previously discussed, 12,012 heads were obtained in 24,000 throws of a coin to produce a probability of 12,012/24,000 = 0.5005. If an event occurs say three times in an infinite number of trials, its probability is zero, i.e., $3/\infty = 0$. Try breaking a piece of chalk at exactly the same cross-section more than once. There are an infinite number of sections along the length of the chalk where failure can occur. It is possible to achieve a finite number of identical breaks in an infinite number of trials hence, zero probability. Consider that 3,000,000,000,000 meteorites have



NOTES:
1. Accident Frequency Rate is defined as the number of disabling injuries per 1,000,000 hours of employee exposure.
2. Incidence Rate is defined as the number of recordable injury cases per 200,000 hours of employee exposure.
3. 1926-1976 Accident Frequency Rate (USAS Z16.1 - 1967)
4. Incidence Rate X 5 (ANSI Z16.4 - 1977)

Figure 2 – Accident Frequency Rate - Machinery

created craters on the moon's surface at least one meter in diameter.[6] And yet, no one on earth has been struck by a meteorite. We would say that within a reasonable degree of technical certainty such an accident has zero probability of happening; nevertheless, we know it's possible since meteorites are on display in museums.

Conclusion 7: **The unforeseeable may occur.**

Conclusion 8: **Zero probability does not infer impossibility.**

VII. Reasonably Foreseeable Use

There are two meanings for the word "reasonable" that are useful in the context of reasonable foreseeability. The first is related to reason and sound judgement and is found in such doctrines as reasonable cause, reasonable expectation, reasonable man, and reasonable use. The second explicitly focuses on magnitude modified by the property of being fair, proper, just, moderate, or not excessive. It is used in such doctrines as reasonable care, reasonable doubt, reasonable force and reasonable time. Because foreseeability requires a pattern of events, any size property of the pattern is modified by the adjective reasonable.

Deaths caused by vehicle collisions with pedestrians are reported every year. Were they reasonably foreseeable in 1976? Expressed as a percentage of the total vehicle- related deaths, the historical pedestrian-collision rates were 18.0% (1968), 18.1% (1969), 18.1% (1970), 18.2%, (1971), 18.3%, (1972), 18.4%, (1973), 18.3%, (1974), 18.3%, (1975) and 18.3%, (1976).[5] Clearly, a pattern exists and the deaths are foreseeable. Is the magnitude of this foreseeable tragedy reasonable, or put in another context, would a jury find eight-to-nine thousand deaths per year a reasonably large number? Assuming they would, could 1976 technology solve the problem?

Consider the strangulation of children on cords which hang from window coverings such as blinds, shades, curtains and

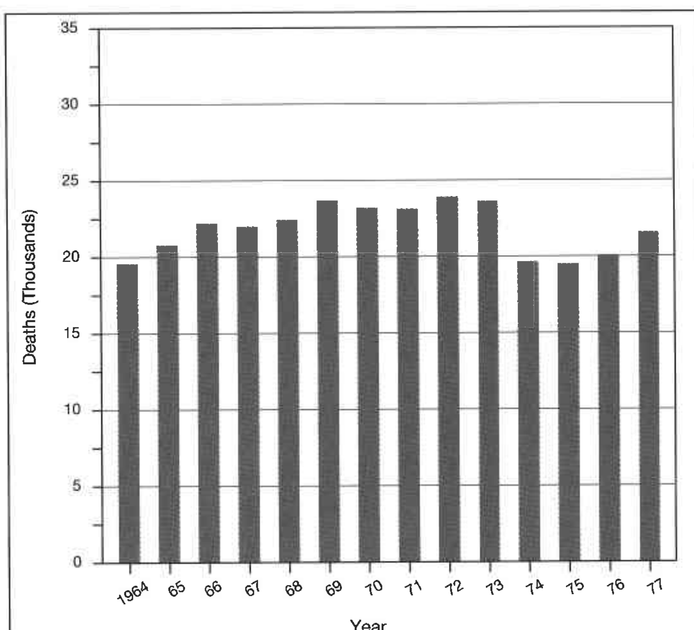


Figure 3 – Motor Vehicle Deaths Caused by Collisions with Other Vehicles, 1964 - 1977.

the like. From 1981 to 1995 the Consumer Product Safety Commission (CPSC) recorded 150 deaths to children below the age of five (5).[7] Children below five (5) years of age are exposed to window cords one trillion hours per year. Surely with such a massive sampling the deaths per year should exhibit statistical regularity; but, it doesn't. Both the number of yearly deaths and their causes vary significantly. Specific data on yearly deaths were found to be 15 (1991), 17 (1992), 6 (1993), and 9 (1995). The CPSC has projected 12 strangulations per year; the Journal of the American Medical Association projects 24 per year. The high-to-low ratio is four (4). This is not foreseeable behavior, it is random behavior, i.e., without definite aim, direction, rule, method, or pattern. Recall the legal definition of foreseeability; that which is objectively reasonable to expect, not merely what might conceivably occur. Further, the AFR for such strangulations is one-millionth the current "All Industries" AFR. Because the AFR is de minimus, it might be judged unreasonable to address the cord strangulation problem, given the nation's limited resources to deal with carnage, e.g., 40 to 50 million annual automotive deaths.

There are literally hundreds of millions of window cords in American homes today that have conspired to produce a near-perfect system; it is very difficult to improve on such perfection (Law of Diminishing Returns). Nevertheless, in 1985, the CPSC began a significant program to reduce strangulation from window coverings; unfortunately, no improvement has been demonstrated in the last fourteen years.

To illustrate the differences among expected and foreseeable uses, consider the design of a screwdriver. The expected use of this tool is to transfer torque from the hand to the head of a screw. This can be accomplished inexpensively using a cast iron blade. If such a screwdriver is misused as a "crowbar" for prying open windows, or opening lids on paint cans, or removing hubcaps, the blade may fracture and become a dangerous missile because of its frangible material. There is, of course, a sizeable pattern of users who place the screwdriver blade in bending in addition to torsion; consequently, the designer must address this reasonably foreseeable application. This is accomplished by adopting a more expensive ductile blade which bends without fracturing.

We now treat the contingency that the screwdriver will be used to clean out a person's ear. Certainly this is possible and surely it has on occasion been so misused. On the other hand, no pattern has been observed of such an application and furthermore, such behavior has been very, very rare. Thus, it is not reasonably foreseeable that a screwdriver will be used for cleaning ears and the designer need not incorporate a cotton swab holder in the handle of every screwdriver.

DEFINITION OF A SAFETY PROBLEM

Since it is axiomatic that every work of humankind and nature is capable of causing harm, should designers consider every potential safety problem? The answer cannot be found in technology. It is currently provided in law; if it is not reasonably foreseeable, it is not a safety problem. It is expected and therefore reasonably foreseeable that machinery operators will place themselves at various times in the neighborhood of control stations. At such times, it is possible for overhead cranes to drop loads on these operators and for forklift trucks to skewer or crush them. Indeed, such mischief is well documented. Should we build a redoubt about every work station in our factories? Because such accident scenarios are infrequent and random, they are not reasonably foreseeable and do not require redress.

Conclusion 9:	**Absent a sizeable mischief pattern, no safety problem exists.**

DELUSIONS

In order to establish that a design is dangerously defective, it is often necessary for attorneys to prove that it does not eliminate dangers arising from its reasonably foreseeable use and misuse. Often the theory of persuasion is pursued more vigorously than the actual proof. A few of the settings where this problem manifests itself are briefly discussed.

Possible/Foreseeable Interchange

A manufacturer of a challenged design has notice of a fact if he knows the fact, has reason to know it, should know it, or has been given notification of it. To persuade a jury that a safety problem is reasonably foreseeable, some plaintiffs merely establish that a manufacturer has notice. The fact is that notice only proves what may possibly or conceivably occur. What is required is a demonstration of a sizeable or reasonable pattern of accidents arising from the problem.

Questioning of a company engineer in a product liability case involving a unique accident scenario often proceeds along the following lines:

Q. Is it true that your company has produced this product for 31 years?
A. Yes.

Q. If I understood your direct examination correctly, you testified that this accident was not foreseeable because you have never seen or heard of it before?
A. That's correct.

Q. Have you investigated the accident in the pending case?
A. I have.

Q. Would you now say that this accident is foreseeable to you?
A. Now that I've seen it, yes, I would.

The plaintiff's attorney has now incorrectly established, in the eyes of the jury, that the accident is foreseeable. In fact, the accident is merely possible and has manifested itself as a random event.

Foreseeable v. Reasonably Foreseeable

In the hope that juries cannot distinguish between foreseeability and the actual legal requirement of reasonable foreseeability, questioning of all witnesses often proceeds using the term foreseeability alone. It is usually impossible to prove reasonableness in the case of misuse because it is very rare. One of the more unsavory trial techniques for proving foreseeability embraces Murphy's Law, i.e., anything that can go wrong will go wrong. It makes the leap from mere possibility to certainty. Murphy's Law is particularly misleading because juries are generally familiar with it and its numerous corollaries and they believe it's a scientific law. The fact is Murphy's Law is a joke; it is not a scientific relationship. Furthermore, it is almost always incorrect. For example, are we all going to be killed by an automobile, a plane crash, a drive-by shooting, an attack dog or a collapsing building?

Absolute Liability

A one-ton crane hook with a safety factor of three was subjected to a five-ton load which broke the hook and caused an injury. It was argued that this misuse was foreseeable and that the safety factor was too small. The manufacturer increased the safety factor to six, whereupon another injury occurred during an eight-ton lift. The foreseeable misuse argument continues *adnauseam* leading to absolute liability. The author bears witness to a case where the hook's safety factor is 17.5 with a commensurate cost multiplier. It is unethical to use these outsized safety factors because the cost of the hooks is passed on to all users, the vast majority of whom use the hooks to carry one-ton and not 17.5 tons. Recalling the first canon of ethics for engineers, can the economic welfare of the public be served, let alone be held paramount, in the present example of excessive cost stemming from excessive safety?

Bypassing Safeguards

Product liability lawsuits in the 1990's typically involve circumvention of one or more safeguarding systems which would have prevented the accidents being adjudicated. As an example, a hinged and interlocked barrier guard is removed from a machine with "on product" warnings not to remove guards or bypass interlocks. It is usually argued that it is foreseeable (not reasonably foreseeable) that operators will circumvent such systems. There is, of course, no theoretical solution to such cascading misuses if each step is deemed to be foreseeable.

In cases of this type, the first definition of reasonable may be appropriate, i.e., involving reason and sound judgement. We would raise the following questions: should a manufacturer care more about a person's safety than the person? Would a reasonable person under like or similar circumstances bypass all of the safeties? Is it reasonable for workers to violate their state and national workplace laws?

The diverging nature of foreseeable misuse has recently been eliminated in Louisiana where the doctrine of "Reasonable Anticipated Use" has been adopted.[8,9] "The phrase, reasonable anticipated use under products liability statute creates a more restrictive scope of liability conveying the message that a manufacturer is not responsible for accounting for every conceivable foreseeable use of the product." The standard is reasonableness, not foreseeability.

From a purely semantic point of view, the term reasonably anticipated use is entirely equivalent to the term reasonably foreseeable use. The behavior of technologists is guided by the law — what is not understood or what is misconstrued profoundly effects their mission to serve humankind.

Overly Broad Questions

Is it foreseeable that people make mistakes? The answer to this hopelessly broad question is No. It is possible for people to make mistakes; but, there is no pattern whose size we can forecast to ask if it's reasonable. For example, what percentage of people make mistakes? One could, on the other hand, ask what percentage of people make a particular mistake? If this percentage is stable, this particular mistake is foreseeable. Countermeasures cannot be developed for broad collections of human errors.

Is it foreseeable that drivers will depress the accelerator when they intend to step on the brake pedal? The answer to this narrow question is Yes. There is a pattern for this type of slip and the pattern has a magnitude that may be expressed as "percentage of slips during brake applications." The reasonableness may be judged and if found wanting, a redesign protocol can be developed.

In general, large collections of failure modes do not lend themselves to a population that can be characterized statistically. They usually, however, contain individual failure modes that are foreseeable using inference techniques. If all of the failure modes in a collection are foreseeable and if their mix remains constant, the collection itself becomes foreseeable.

CONCLUSIONS

A. The tort system has formulated various analysis doctrines for determining whether a product is defective; e.g., negligence, strict liability, risk-utility, comparative fault and alternative design.[10] In all of these, the concept of reasonably foreseeable use is central to the identification of safety problems that should or should not be addressed by technologists. Warranty is the only doctrine which is generally independent of the reasonably foreseeable use concept.

To redress an ever widening set of injury claims, the plaintiff's bar is continually exerting pressure to extend reasonably foreseeable use to more and more bizarre circumstances. The past three decades have found, by and large, that every machine is safeguarded and on-product warnings adorn every work of technology. These safety systems arise because they are demanded by various value systems in our society; regulatory bodies, consensus groups, legislative bodies, judicial value systems and ethical and religious systems. As a consequence, the underlying accident scenarios that predominate recent cases involve misuse; usually multiple misuse; e.g., simultaneously removing barrier guards and ignoring both on-product and in-manual warnings.

With respect to this misuse situation, technologists are simply unable to properly protect the public and manufacturers against insidious encroachment into the land of unreasonably foreseeable use. Their effectiveness is compromised by some of the following factors:

1. Increasing a product's cost to redress a really rare mishap violates the engineering codes of ethics.
2. Rare misuses are rarely uncovered in the laboratory or in the design setting; poorly studied and poorly documented feedback from the field is the primary source of misuse information.

3. The status of statistical information in this country is so impoverished that it is almost impossible to judge "reasonableness."
4. The power and latitude given to plaintiff's attorneys when cross-examining technologists is simply overwhelming to the unskilled witness.
5. Courtroom trials always favor plaintiff's attorneys; technology is never presented on a level playing field.
6. The average communication skills of technologists pale before those of legal practitioners.
7. On average, attorneys are better educated than technologists especially in those areas that matter most in a courtroom.
8. The technologist is under oath; the plaintiff's attorney is not.
9. The technologist must remain consistent from trial to trial and from deposition to deposition; the plaintiff's attorney may vary his or her position from case to case.
10. The term "reasonably foreseeable use" is not defined for technologists.
11. The concept of foreseeability is very technical; it is certainly not understood by either technology or the law.
12. The judgement of reasonableness is entirely subjective and is usually decided by juries.
13. The theory of persuasion and its associated trial techniques predominate the presentation of reasonably foreseeable use.

In the face of the foregoing realities, the technologist is impotent. Perhaps the discipline associated with this paper in establishing the foundations of reasonably foreseeable use taken together with its exposure of false arguments can aid the courts, juries and defense attorneys in bringing truth and sanity back into our products liability system.

B. Restatement of the Law Third, Torts: Products Liability,[11] recently promulgated by The American Law Institute, applies the adjectives reasonable and foreseeable to phrases containing the word risk. For example:

magnitude of foreseeable risk,

foreseeability of risk,

foreseeable risk of harm,

minimizing the foreseeable risk of danger,

risks were reasonably foreseeable.

Strictly speaking, these phrases cannot be defined from known meanings of the words. On the other hand, if we adopt a less pedantic outlook we may observe from the content of the Restatement that the phrases all connote harm or its magnitude. The notion of harm must enter the phrases through the word risk and, consequently, we are led to one of its classic engineering definitions. Risk, or its antonym, safety, is a function of severity of harm, i.e., "how badly are you hurt?" and frequency of harm, i.e., "how often are you hurt?".[10] Observe that the existence and computation of frequency (or probability) of harm is identical to establishing foreseeability of harm (e.g., the existence of a stable population of events).

Drop the word foreseeable from all of the cited phrases and they all acquire meaning. If risk can be calculated, one may ask if its magnitude is reasonable.

Conclusion 10: The definition of risk implies foreseeability.

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	4	*Voltaire –* **"The best is the enemy of the good."**
	5	*Ralph Waldo Emerson –* **"A foolish consistency is the hobgoblin of little minds."**
	6	*Ralph L. Barnett –* **"If you want full credit for your work, screw it up."**
	7	*Thomas Henry Huxley (1825-1895) –* **"The great tragedy of Science – the slaying of a beautiful hypothesis by an ugly fact."**
	8	*Jewish Proverb –* **"Guilt is the gift that keeps on giving."**
	9	*Anonymous –* **"There's never enough time to do it right, but there's always enough time to do it over."**
	10	*Mark Twain –* **"Man was made at the end of the week's work, when God was tired."**
	11	*Niels Bohr, Physicist (1885-1962) –* **"Never express yourself more clearly than you think."**
	12	*Rudyard Kipling, Plain Tales from the Hills, 1888 –* **"A woman's guess is much more accurate than a man's certainty."**
	13	*Calvin Coolidge –* **"When I hear, I forget When I see, I remember When I do, I understand."**
	14	*Albert Einstein –* **"Against every great and noble endeavor are a thousand mediocre minds."**
	15	*Omar Khayyam, The Rubaiyat –* **"The Moving Finger writes; and, having writ, Moves on: nor all your Piety nor Wit, Shall lure it back to cancel half a Line, Nor all your Tears wash out a Word of it."**
	16	*Goethe, Maxims and Reflections, early 19th century –* **"All professional men are handicapped by not being allowed to ignore things which are useless."**
	17	*Anne Frank –* **"How wonderful it is that nobody need wait a single moment before starting to improve the world."**
	18	*Sir Arthur Conan Doyle, Sherlock Holmes –* **"When you have eliminated the impossible, whatever remains, however improbable, must be the truth"**
	19	*High Road to China (S.W. Roland/S.L. Pogostin) –* **"The oxen are slow but the earth is patient."**
	20	*Louis Pasteur –* **"Chance favors only the prepared mind."** (Le hasard ne favorise que les espirit prepares.")
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