Live Webinar: Engineering Ethics

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National Society of Professional Engineers®

Code of Ethics for Engineers

Preamble

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.
   a. If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.
   b. Engineers shall approve only those engineering documents that are in conformity with applicable standards.
   c. Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or this Code.
   d. Engineers shall not permit the use of their name or associate in business ventures with any person or firm that they believe is engaged in fraudulent or dishonest enterprise.
   e. Engineers shall not aid or abet the unlawful practice of engineering by a person or firm.
   f. Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the proper authorities in furnishing such information or assistance as may be required.
2. Engineers shall perform services only in the areas of their competence.
   a. Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved.
   b. Engineers shall not affix their signatures to any plans or documents dealing with subject matter in which they lack competence, nor to any plan or document not prepared under their direction and control.
   c. Engineers may accept assignments and assume responsibility for coordination of an entire project and sign and seal the engineering documents for the entire project, provided that each technical segment is signed and sealed only by the qualified engineers who prepared the segment.
3. Engineers shall issue public statements only in an objective and truthful manner.
   a. Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current.
   b. Engineers may express publicly technical opinions that are founded upon knowledge of the facts and competence in the subject matter.
   c. Engineers shall issue no statements, criticisms, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.
4. Engineers shall act for each employer or client as faithful agents or trustees.
   a. Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.
   b. Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.
   c. Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible.
   d. Engineers in public service as members, advisors, or employees of a governmental or quasi-governmental body or department shall not participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice.
   e. Engineers shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member.
5. Engineers shall avoid deceptive acts.
   a. Engineers shall not falsify their qualifications or permit misrepresentation of their or their associates' qualifications. They shall not misrepresent or exaggerate their responsibility in or for the subject matter of prior assignments. Brochures or other presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, joint venturers, or past accomplishments.
   b. Engineers shall not offer, give, solicit, or receive, either directly or indirectly, any contribution to influence the award of a contract by public authority, or which may be reasonably construed by the public as having the effect or intent of influencing the awarding of a contract. They shall not offer any gift or other valuable consideration in order to secure work. They shall not pay a commission, percentage, or brokerage fee in order to secure work, except to a bona fide employee or bona fide established commercial or marketing agencies retained by them.

III. Professional Obligations

1. Engineers shall be guided in all their relations by the highest standards of honesty and integrity.
   a. Engineers shall acknowledge their errors and shall not distort or alter the facts.
   b. Engineers shall advise their clients or employers when they believe a project will not be successful.
   c. Engineers shall not accept outside employment to the detriment of their regular work or interest. Before accepting any outside engineering employment, they will notify their employers.
   d. Engineers shall not attempt to attract an engineer from another employer by false or misleading pretenses.
   e. Engineers shall not promote their own interest at the expense of the dignity and integrity of the profession.
2. Engineers shall at all times strive to serve the public interest.
   a. Engineers are encouraged to participate in civic affairs; career guidance for youths; and work for the advancement of the safety, health, and well-being of their community.
   b. Engineers shall not complete, sign, or seal plans and/or specifications that are not in conformity with applicable engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project.
   c. Engineers are encouraged to extend public knowledge and appreciation of engineering and its achievements.
   d. Engineers are encouraged to adhere to the principles of sustainable development[1] in order to protect the environment for future generations.

3. Engineers shall avoid all conduct or practice that deceives the public.
   a. Engineers shall avoid the use of statements containing a material misrepresentation of fact or omitting a material fact.
   b. Consistent with the foregoing, engineers may advertise for recruitment of personnel.
   c. Consistent with the foregoing, engineers may prepare articles for the lay or technical press, but such articles shall not imply credit to the author for work performed by others.
4. Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.
   a. Engineers shall not, without the consent of all interested parties, promote or arrange for new employment or practice in connection with a specific project for which the engineer has gained particular and specialized knowledge.
   b. Engineers shall not, without the consent of all interested parties, participate in or represent an adversary interest in connection with a specific project or proceeding in which the engineer has gained particular specialized knowledge on behalf of a former client or employer.
5. Engineers shall not be influenced in their professional duties by conflicting interests.
   a. Engineers shall not accept financial or other considerations, including free engineering designs, from material or equipment suppliers for specifying their product.
   b. Engineers shall not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with clients or employers of the engineer in connection with work for which the engineer is responsible.
6. Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.
   a. Engineers shall not request, propose, or accept a commission on a contingent basis under circumstances in which their judgment may be compromised.
   b. Engineers in salaried positions shall accept part-time engineering work only to the extent consistent with policies of the employer and in accordance with ethical considerations.
   c. Engineers shall not, without consent, use equipment, supplies, laboratory, or office facilities of an employer to carry on outside private practice.
7. Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.
   a. Engineers in private practice shall not review the work of another engineer for the same client, except with the knowledge of such engineer, or unless the connection of such engineer with the work has been terminated.
   b. Engineers in governmental, industrial, or educational employ are entitled to review and evaluate the work of other engineers when so required by their employment duties.
   c. Engineers in sales or industrial employ are entitled to make engineering comparisons of represented products with products of other suppliers.
8. Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.
   a. Engineers shall conform with state registration laws in the practice of engineering.
   b. Engineers shall not use association with a nonengineer, a corporation, or partnership as a "cloak" for unethical acts.
9. Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.
   a. Engineers shall, whenever possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments.
   b. Engineers using designs supplied by a client recognize that the designs remain the property of the client and may not be duplicated by the engineer for others without express permission.
   c. Engineers, before undertaking work for others in connection with which the engineer may make improvements, plans, designs, inventions, or other records that may justify copyrights or patents, should enter into a positive agreement regarding ownership.
   d. Engineers' designs, data, records, and notes referring exclusively to an employer's work are the employer's property. The employer should indemnify the engineer for use of the information for any purpose other than the original purpose.
   e. Engineers shall continue their professional development throughout their careers and should keep current in their specialty fields by engaging in professional practice, participating in continuing education courses, reading in the technical literature, and attending professional meetings and seminars.

Footnote 1 "Sustainable development" is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development.

As Revised July 2007

"By order of the United States District Court for the District of Columbia, former Section 11(c) of the NSPE Code of Ethics prohibiting competitive bidding, and all policy statements, opinions, rulings or other guidelines interpreting its scope, have been rescinded as unlawfully interfering with the legal right of engineers, protected under the antitrust laws, to provide price information to prospective clients; accordingly, nothing contained in the NSPE Code of Ethics, policy statements, opinions, rulings or other guidelines prohibits the submission of price quotations or competitive bids for engineering services at any time or in any amount."

Statement by NSPE Executive Committee

In order to correct misunderstandings which have been indicated in some instances since the issuance of the Supreme Court decision and the entry of the Final Judgment, it is noted that in its decision of April 25, 1978, the Supreme Court of the United States declared: "The Sherman Act does not require competitive bidding."

It is further noted that as made clear in the Supreme Court decision:
1. Engineers and firms may individually refuse to bid for engineering services.
2. Clients are not required to seek bids for engineering services.
3. Federal, state, and local laws governing procedures to procure engineering services are not affected, and remain in full force and effect.
4. State societies and local chapters are free to actively and aggressively seek legislation for professional selection and negotiation procedures by public agencies.
5. State registration board rules of professional conduct, including rules prohibiting competitive bidding for engineering services, are not affected and remain in full force and effect. State registration boards with authority to adopt rules of professional conduct may adopt rules governing procedures to obtain engineering services.
6. As noted by the Supreme Court, "nothing in the judgment prevents NSPE and its members from attempting to influence governmental action . . ."

Note: In regard to the question of application of the Code to corporations vis-a-vis real persons, business form or type should not negate nor influence conformance of individuals to the Code. The Code deals with professional services, which services must be performed by real persons. Real persons in turn establish and implement policies within business structures. The Code is clearly written to apply to the Engineer, and it is incumbent on members of NSPE to endeavor to live up to its provisions. This applies to all pertinent sections of the Code.

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Credit for Engineering Work – Design Competition

FACTS:

Engineer A is retained by a city to design a bridge as part of an elevated highway system. Engineer A then retains the services of Engineer B, a structural engineer with expertise in horizontal geometry, superstructure design and elevations to perform certain aspects of the design services. Engineer B designs the bridge's three curved welded plate girder spans which were critical elements of the bridge design.

Several months following completion of the bridge, Engineer A enters the bridge design into a national organization's bridge design competition. The bridge design wins a prize. However, the entry fails to credit Engineer B for his part of the design.

QUESTION:

Was it ethical for Engineer A to fail to give credit to Engineer B for his part in the design?

REFERENCES:

Section I.3. -Issue public statements only in an objective and truthful manner.

Section II.3.a. -Engineers shall be objective and truthful in professional reports, statements or testimony. They shall include all relevant and pertinent information in such reports, statements or testimony.

Section III.3. -Engineers shall avoid all conduct or practice which is likely to discredit the profession or deceive the public.

Section III.5.a. -Engineers shall not accept financial or other considerations, including free engineering designs, from material or equipment suppliers for specifying their product.

Section III.10.a. -Engineers shall, whenever possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments.

DISCUSSION:

Basic to engineering ethics is the responsibility to issue statements in an objective and truthful manner (Section I.3.) The concept of providing credit for engineering work to those to whom credit is due is fundamental to that responsibility. This is particularly the case where an engineer retains the services of other individuals because the engineer may not possess the education, experience and expertise to perform the required services for a client. The engineer has an obligation to the client to make this information known (Section II.3.a.) As noted in BER Case 71-1, the principle is not only fair and in the best interests of the profession, but it also recognizes that the professional engineer must assume personal responsibility for his decisions and actions.

A city department of public works retained Firm A to prepare plans and specifications for a water extension project. Engineer B, chief engineer of the department having authority in such matters, instructed Firm A to submit its plans and specifications without showing the name of the firm on the cover sheets but permitted the firm to show the name of the firm on the working drawings. It was also the policy of the department not to show the name of the design firm in the advertisements for construction bids, in fact, the advertisements stated "plans and specifications as prepared by the city department of public works." The Board noted that the policy of the department is, at best, rather unusual in normal engineering practices and relationships between retained design firms and clients. The Board surmised on the basis of the submitted facts that the department policy was intended to reflect the idea that the plans and specifications when put out to construction bid are those of the department. In concluding that Engineer B acted unethically in adopting and implementing a policy which prohibited the identification of the design firm on the cover sheets for plans and specification, the Board noted that Engineer B, in carrying out the department policy, denied credit to Firm A for its work. The Code of Ethics Section III.10.a. states that engineers shall, whenever possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments. The Board concluded that under the circumstances, it was possible for Engineer B to name the persons responsible for the design.

While each individual case must be understood based upon the particular facts involved, we believe that Engineer A had an ethical obligation to his client, to Engineer B as well as to the public to take reasonable steps to identify all parties responsible for the design of the bridge.

CONCLUSION:

It was unethical for Engineer A to fail to give credit to Engineer B for his part in the design.

BOARD OF ETHICAL REVIEW William A. Cox, Jr., P.E., William W. Middleton, P.E., William E. Norris, P.E., William F. Rauch, Jr., P.E., Jimmy H. Smith, P.E., Otto A. Tennant, P.E., Robert L. Nichols, P.E., Chairman

Note:

In regard to the question of application of the Code to corporations vis-a-vis real persons, business form or type should not negate nor influence conformance of individuals to the Code. The Code deals with professional services, which services must be performed by real persons. Real persons in turn establish and implement policies within business structures. The Code is clearly written to apply to the Engineer and it is incumbent on a member of NSPE to endeavor to live up to its provisions. This applies to all pertinent sections of the Code.

Gift—Complimentary Seminar Registration

Facts:

The ABC Pipe Company is interested in becoming known within the engineering community and, in particular, to those engineers involved in the specification of pipe in construction. ABC would like to educate engineers about the various products available in the marketplace: the advantages and disadvantages of using one type of pipe over another. ABC sends an invitation to Engineer A, as well as other engineers in a particular geographic area, announcing a one-day complimentary educational seminar to educate engineers on current technological advances in the selection and use of pipe in construction. ABC will host all refreshments, buffet luncheon during the seminar, and a cocktail reception immediately following. Engineer A agrees to attend.

Question:

Was it ethical for Engineer A to attend the one-day complimentary educational seminar hosted by the ABC Pipe Company?

References:

Code of Ethics - Section II.4.c. - "Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from contractors, their agents, or other parties in connection with work for employers or clients for which they are responsible."

Section III.5.b. "Engineers shall not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with clients or employers of the Engineer in connection with work for which the Engineer is responsible."

Section III.11.a. "Engineers shall encourage engineering employees' efforts to improve their education."

Discussion

Ethical concerns relating to the issue of gifts and other consideration provided by suppliers to engineers are addressed in several sections of the NSPE Code. Obviously, instances where gifts or other property of monetary value are exchanged between an engineer and a potential client are extremely sensitive and do require careful scrutiny to determine if such exchanges are proper. In the past, this Board has examined the question from two perspectives: (1) where an engineer provides a client with a gift or valuable consideration under circumstances that could create the appearance of seeking to influence the client's judgment, and (2) where a supplier provides the engineer with a gift or valuable consideration under circumstances that could create an appearance that the supplier was seeking to influence the engineer's judgment. The instant case relates to the latter situation.

In Case 60-9 the Board examined a situation involving certain engineering employees of an industrial firm who were in a position to recommend for or against the purchase of products used by the company. They regularly received cash gifts ranging from $25 to $100 from product salesmen. In ruling that accepting those gifts was not ethical, the Board noted that an occasional free luncheon or dinner, and a Christmas or birthday present when there is a personal relationship, are acceptable practice. On the other hand, cash payments to those in a position to influence decisions favorable or unfavorable to the giver are not in good taste and do immediately raise the suspicion of an ulterior motive.

More recently, in Case 81-4, this Board dealt with three engineers who were principals or employees of a consulting engineering firm that did an extensive amount of design work for private developers. The engineers were involved in recommending to the developers a list of contractors and suppliers to be considered for selection on a bidding list for construction of some projects. Usually, those the engineers recommended obtained most of the contracts from the developers. Over a period of years, the officers of the contractors or suppliers developed a close business and personal relationship with the engineers. From time to time, at holidays or on the engineers' birthdays, the contractors and suppliers would give them personal gifts of substantial value, such as house furnishings, recreational equipment, or gardening equipment. In finding that it was unethical for the engineers to accept those gifts, we stated that engineers should "lean over backward" to avoid acceptance of gifts from those with whom they, or their firm, do business.

At that time, the Board again noted that there may be circumstances when a gift is permissible, as stated in Case 60-9, and does not compromise the engineer's independent professional judgment.

The Code unequivocally states that engineers must not accept gifts or other valuable consideration from a supplier in exchange for specifying its products. (See Sections II.4.c.; III.5.b.) However, in this case we are dealing with a material supplier who is introducing information about pipe products to engineers in the community and has chosen the form of an educational seminar as its vehicle. While ABC Pipe Company will seek to present its particular products in a favorable light and point out their many advantages over others', a complimentary invitation to such a seminar would not reach the level that would raise an ethical concern. The earlier decisions and the pertinent provisions of the Code relate more to the circumstances in which valuable gifts are received and at least create the appearance of a "quid pro quo" or an exchange of valuable consideration for specifying the equipment. Under the facts of this case, Engineer A is accepting an opportunity to become educated on a particular topic consistent with Section III.11.a. of the Code. He would be attending the seminar with many of his colleagues, and there is no suggestion in the facts that anyone at ABC Pipe Company would personally seek to persuade Engineer A to specify its products.

We view the buffet luncheon and cocktail reception immediately following the seminar as falling within the de minimis provisions noted earlier in Cases 60-9 and 81-4, and thus it would not be improper for Engineer A to participate in those activities. We note, however, that had Engineer A agreed to accept items of substantial value (e.g., travel expenses, multi-day program, resort location, etc.) our conclusion would have been quite different.

Conclusion

It was ethical for Engineer A to attend the one-day complimentary educational seminar hosted by the ABC Pipe Company.

Note: This opinion is based on data submitted to the Board of Ethical Review and does not necessarily represent all of the pertinent facts when applied to a specific case. This opinion is for educational purposes only and should not be construed as expressing any opinion on the ethics of specific individuals. This opinion may be reprinted without further permission, provided that this statement is included before or after the text of the case.

Board of Ethical Review: Eugene N. Bechamps, P.E., Robert J. Haefeli, P.E., Ernest C. James, P.E., Robert W. Jarvis, P.E., J. Kent Roberts, P.E., Everett S. Thompson, P.E.,

Whistleblowing

Engineer A is employed by a large industrial company which engages in substantial work on defense projects. Engineer A's assigned duties relate to the work of subcontractors, including review of the adequacy and acceptability of the plans for material provided by subcontractors. In the course of this work Engineer A advised his superiors by memoranda of problems he found with certain submissions of one of the subcontractors, and urged management to reject such work and require the subcontractors to correct the deficiencies he outlined. Management rejected the comments of Engineer A, particularly his proposal that the work of a particular subcontractor be redesigned because of Engineer A's claim that the subcontractor's submission represented excessive cost and time delays.

After the exchange of further memoranda between Engineer A and his management superiors, and continued disagreement between Engineer A and management on the issues he raised, management placed a critical memorandum in his personnel file, and subsequently placed him on three months' probation, with the further notation that if his job performance did not improve, he would be terminated.

Engineer A has continued to insist that his employer had an obligation to insure that subcontractors deliver equipment according to the specifications, as he interprets same, and thereby save substantial defense expenditures. He has requested an ethical review and determination of the propriety of his course of action and the degree of ethical responsibility of engineers in such circumstances.

Question:
Does Engineer A have an ethical obligation, or an ethical right, to continue his efforts to secure change in the policy of his employer under these circumstances, or to report his concerns to proper authority?

References:
Code of Ethics - Section II.1.a. - "Engineers shall at all times recognize that their primary obligation is to protect the safety, health, property, and welfare of the public. If their professional judgment is overruled under circumstances where the safety, health, property, or welfare of the public are endangered, they shall notify their employer or client and such other authority as may be appropriate."

Section III.2.b. - "Engineers shall not complete, sign, or seal plans and/or specifications that are not of a design safe to the public health and welfare and in conformity with accepted engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project."

Discussion:
In Case 65-12 we dealt with a situation in which a group of engineers believed that a product was unsafe, and we determined that so long as the engineers held to that view they were ethically justified in refusing to participate in the processing or production of the product in question. We recognized in that case that such action by the engineers would likely lead to loss of employment.

In Case 61-10 we distinguished a situation in which engineers had objected to the redesign of a commercial product, but which did not entail any question of public health or safety. On that basis we concluded that this was a business decision for management and did not entitle the engineers to question the decision on ethical grounds.

The Code section in point related to plans and specifications "that are not of a design safe to the public health and welfare," and ties that standard to the ethical duty of engineers to notify proper authority of the dangers and withdraw from further service on the project.

That is not quite the case before us; here the issue does not allege a danger to public health or safety, but is premised upon a claim of unsatisfactory plans and the unjustified expenditure of public funds. We could dismiss the case on the narrow ground that the Code does not apply to a claim not involving public health or safety, but we think that is too narrow a reading of the ethical duties of engineers engaged in activities having a substantial impact on defense expenditures or other substantial public expenditures that relate to "welfare" as set forth in Section III.2.b.

The situation presented here has become well known in recent years as whistleblowing", and we note that there have been several cases evoking national interest in the defense field. As we recognized in earlier cases, if an engineer feels strongly that an employer's course of conduct is improper when related to public concerns, and if the engineer feels compelled to blow the whistle to expose the facts as he sees them, he may well have to pay the price of loss of employment. In some of the more notorious cases of recent years engineers have gone through such experiences and even if they have ultimately prevailed on legal or political grounds, the experience is not one to be undertaken lightly.

In this type of situation, we feel that the ethical duty or right of the engineer becomes a matter of personal conscience, but we are not willing to make a blanket statement that there is an ethical duty in these kinds of situations for the engineer to continue his campaign within the company, and make the issue one for public discussion. The Code only requires that the engineer withdraw from a project and report to proper authorities when the circumstances involve endangerment of the public health, safety, and welfare.

Conclusion:
Engineer A does not have an ethical obligation to continue his effort to secure a change in the policy of his employer under these circumstances, or to report his concerns to proper authority, but has an ethical right to do so as a matter of personal conscience.

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Board of Ethical Review: Ernest C. James, P.E., Lawrence E. Jones, P.E., Robert H. Perrine, P.E., James L. Polk, P.E., J. Kent Roberts, P.E., Alfred H. Samborn, P.E., F. Wendell Beard, P.E., chairman

ENGINEERING ETHICS

The Space Shuttle Challenger Disaster

Department of Philosophy and Department of Mechanical Engineering
Texas A&M University
NSF Grant Number
DIR-9012252

Instructor's Guide

Introduction To The Case

On January 28, 1986, seven astronauts were killed when the space shuttle they were piloting, the Challenger, exploded just over a minute into the flight. The failure of the solid rocket booster O-rings to seat properly allowed hot combustion gases to leak from the side of the booster and burn through the external fuel tank. The failure of the O-ring was attributed to several factors, including faulty design of the solid rocket boosters, insufficient low- temperature testing of the O-ring material and the joints that the O-ring sealed, and lack of proper communication between different levels of NASA management.

Instructor Guidelines

Prior to class discussion, ask the students to read the student handout outside of class. In class the details of the case can be reviewed with the aide of the overheads. Reserve about half of the class period for an open discussion of the issues. The issues covered in the student handout include the importance of an engineer's responsibility to public welfare, the need for this responsibility to hold precedence over any other responsibilities the engineer might have and the responsibilities of a manager/engineer. A final point is the fact that no matter how far removed from the public an engineer may think she is, all of her actions have potential impact. Essay #6, "Loyalty and Professional Rights" appended at the end of the case listings in this report will be found relevant for instructors preparing to lead class discussion on this case. In addition, essays #1 through #4 appended at the end of the cases in this report will have relevant background information for the instructor preparing to lead classroom discussion. Their titles are, respectively: "Ethics and Professionalism in Engineering: Why the Interest in Engineering Ethics?;" "Basic Concepts and Methods in Ethics," "Moral Concepts and Theories," and "Engineering Design: Literature on Social Responsibility Versus Legal Liability."

Questions for Class Discussion

1. What could NASA management have done differently?
2. What, if anything, could their subordinates have done differently?
3. What should Roger Boisjoly have done differently (if anything)? In answering this question, keep in mind that at his age, the prospect of finding a new job if he was fired was slim. He also had a family to support.
4. What do you (the students) see as your future engineering professional responsibilities in relation to both being loyal to management and protecting the public welfare?

The Challenger Disaster Overheads

1. Organizations/People Involved

2. Key Dates
3. Space Shuttle Solid Rocket Boosters (SRB) Joints
4. Detail of SRB Field Joints
5. Ballooning Effect of Motor Casing
6. Key Issues

ORGANIZATIONS/PEOPLE INVOLVED

Marshall Space Flight Center - in charge of booster rocket development
Larry Mulloy - challenged the engineers' decision not to launch
Morton Thiokol - Contracted by NASA to build the Solid Rocket Booster
Alan McDonald - Director of the Solid Rocket Motors Project
Bob Lund - Engineering Vice President
Robert Ebeling - Engineer who worked under McDonald
Roger Boisjoly - Engineer who worked under McDonald
Joe Kilminster - Engineer in a management position
Jerald Mason - Senior executive who encouraged Lund to reassess his decision not to launch.

KEY DATES

1974 - Morton-Thiokol awarded contract to build solid rocket boosters.
1976 - NASA accepts Morton-Thiokol's booster design.
1977 - Morton-Thiokol discovers joint rotation problem. November 1981 - O-ring erosion discovered after second shuttle flight.
January 24, 1985 - shuttle flight that exhibited the worst O-ring blow-by.
July 1985 - Thiokol orders new steel billets for new field joint design.
August 19, 1985 - NASA Level I management briefed on booster problem.
January 27, 1986 - night teleconference to discuss effects of cold temperature on booster performance.
January 28, 1986 - *Challenger* explodes 72 seconds after liftoff.

KEY ISSUES

HOW DOES THE IMPLIED SOCIAL CONTRACT OF PROFESSIONALS APPLY TO THIS CASE?
WHAT PROFESSIONAL RESPONSIBILITIES WERE NEGLECTED, IF ANY?
SHOULD NASA HAVE DONE ANYTHING DIFFERENTLY IN THEIR LAUNCH DECISION PROCEDURE?

Student Handout - Synopsis

On January 28, 1986, seven astronauts were killed when the space shuttle they were piloting, the *Challenger*, exploded just over a minute into flight. The failure of the solid rocket booster O-rings to seat properly allowed hot combustion gases to leak from the side of the booster and burn through the external fuel tank. The failure of the O-ring was attributed to several factors, including faulty design of the solid rocket boosters, insufficient low temperature testing of the O-ring material and the joints that the O-ring sealed, and lack of communication between different levels of NASA management.

Organization and People Involved

Marshall Space Flight Center - in charge of booster rocket development
Larry Mulloy - challenged the engineers' decision not to launch
Morton Thiokol - Contracted by NASA to build the Solid Rocket Booster
Alan McDonald - Director of the Solid Rocket Motors Project
Bob Lund - Engineering Vice President
Robert Ebeling - Engineer who worked under McDonald
Roger Boisjoly - Engineer who worked under McDonald
Joe Kilminster - Engineer in a management position
Jerald Mason - Senior Executive who encouraged Lund to reassess his decision not to launch.

Key Dates

1974 - Morton-Thiokol awarded contract to build solid rocket boosters.
1976 - NASA accepts Morton-Thiokol's booster design.
1977 - Morton-Thiokol discovers joint rotation problem. November 1981 - O-ring erosion discovered after second shuttle flight. January 24, 1985 - shuttle flight that exhibited the worst O-ring blow-by. July 1985 - Thiokol orders new steel billets for new field joint design.
August 19, 1985 - NASA Level I management briefed on booster problem.
January 27, 1986 - night teleconference to discuss effects of cold temperature on booster performance.
January 28, 1986 - *Challenger* explodes 72 seconds after liftoff.

Background

NASA managers were anxious to launch the *Challenger* for several reasons, including economic considerations, political pressures, and scheduling backlogs. Unforeseen competition from the European Space Agency put NASA in a position where it would have to fly the shuttle dependably on a very ambitious schedule in order to prove the Space Transportation System's cost effectiveness and potential for commercialization. This prompted NASA to schedule a record number of missions in 1986 to make a case for its budget requests. The shuttle mission just prior to the *Challenger* had been delayed a record number of times due to inclement weather and mechanical factors. NASA wanted to launch the *Challenger* without any delays so the launch pad could be refurbished in time for the next mission, which would be carrying a probe that would examine Halley's Comet. If launched on time, this probe would have collected data a few days before a similar Russian probe would be launched. There was probably also pressure to launch *Challenger* so it could be in space when President Reagan gave his State of the Union address. Reagan's main topic was to be education, and he was expected to mention the shuttle and the first teacher in space, Christa McAuliffe. The shuttle solid rocket boosters (or SRBs), are key elements in the operation of the shuttle. Without the boosters, the shuttle cannot produce enough thrust to overcome the earth's gravitational pull and achieve orbit. There is an SRB attached to each side of the external fuel tank. Each booster is 149 feet long and 12 feet in diameter. Before ignition, each booster weighs 2 million pounds. Solid rockets in general produce much more thrust per pound than their liquid fuel counterparts. The drawback is that once the solid rocket fuel has been ignited, it cannot be turned off or even controlled. So it was extremely important that the shuttle SRBs were properly designed. Morton Thiokol was awarded the contract to design and build the SRBs in 1974. Thiokol's design is a scaled-up version of a Titan missile which had been used successfully for years. NASA accepted the design in 1976. The booster is comprised of seven hollow metal cylinders. The solid rocket fuel is cast into the cylinders at the Thiokol plant in Utah, and the cylinders are assembled into pairs for transport to Kennedy Space Center in Florida. At KSC, the four booster segments are assembled into a completed booster rocket. The joints where the segments are joined together at KSC are known as field joints (See Figure 1). These field joints consist of a tang and clevis joint. The tang and clevis are held together by 177 clevis pins. Each joint is sealed by two O rings, the bottom ring known as the primary O-ring, and the top known as the secondary O-ring. (The Titan booster had only one O-ring. The second ring was added as a measure of redundancy since the boosters would be lifting humans into orbit. Except for the increased scale of the rocket's diameter, this was the only major difference between the shuttle booster and the Titan booster.) The purpose of the O-rings is to prevent hot combustion gasses from escaping from the inside of the motor. To provide a barrier between the rubber O-rings and the combustion gasses, a heat resistant putty is applied to the inner section of the joint prior to assembly. The gap between the tang and the clevis determines the amount of compression on the O-ring. To minimize the gap and increase the squeeze on the O-ring, shims are inserted between the tang and the outside leg of the clevis.

Launch Delays

The first delay of the *Challenger* mission was because of a weather front expected to move into the area, bringing rain and cold temperatures. Usually a mission wasn't postponed until inclement weather actually entered the area, but the Vice President was expected to be present for the launch and NASA officials wanted to avoid the necessity of the Vice President's having to make an unnecessary trip to Florida; so they postponed the launch early. The Vice President was a key spokesperson for the President on the space program, and NASA coveted his good will. The weather front stalled, and the launch window had perfect weather conditions; but the launch had already been postponed to keep the Vice President from unnecessarily traveling to the launch site. The second launch delay was caused by a defective micro switch in the hatch locking mechanism and by problems in removing the hatch handle. By the time these problems had been sorted out, winds had become too high. The weather front had started moving again, and appeared to be bringing record-setting low temperatures to the Florida area. NASA wanted to check with all of its contractors to determine if there would be any problems with launching in the cold temperatures. Alan McDonald, director of the Solid Rocket Motor Project at Morton-Thiokol, was convinced that there were cold weather problems with the solid rocket motors and contacted two of the engineers working on the project, Robert Ebeling and Roger Boisjoly. Thiokol knew there was a problem with the boosters as early as 1977, and had initiated a redesign effort in 1985. NASA Level I management had been briefed on the problem on August 19, 1985. Almost half of the shuttle flights had experienced O-ring erosion in the booster field joints. Ebeling and Boisjoly had complained to Thiokol that management was not supporting the redesign task force.

Engineering Design

The size of the gap is controlled by several factors, including the dimensional tolerances of the metal cylinders and their corresponding tang or clevis, the ambient temperature, the diameter of the O-ring, the thickness of the shims, the loads on the segment, and quality control during assembly. When the booster is ignited, the putty is displaced, compressing the air between the putty and the primary O-ring. The air pressure forces the O-ring into the gap between the tang and clevis. Pressure loads are also applied to the walls of the cylinder, causing the cylinder to balloon slightly. This ballooning of the cylinder walls caused the gap between the tang and clevis gap to open. This effect has come to be known as joint rotation. Morton-Thiokol discovered this joint rotation as part of its testing program in 1977. Thiokol discussed the problem with NASA and started analyzing and testing to determine how to increase the O-ring compression, thereby decreasing the effect of joint rotation. Three design changes were implemented:

1. Dimensional tolerances of the metal joint were tightened.
2. The O-ring diameter was increased, and its dimensional tolerances were tightened.
3. The use of the shims mentioned above was introduced. Further testing by Thiokol revealed that the second seal, in some cases, might not seal at all. Additional changes in the shim thickness and O-ring diameter were made to correct the problem.

A new problem was discovered during November 1981, after the flight of the second shuttle mission. Examination of the booster field joints revealed that the O-rings were eroding during flight. The joints were still sealing effectively, but the O-ring material was being eaten away by hot gasses that escaped past the putty. Thiokol studied different types of putty and its application to study their effects on reducing O-ring erosion. The shuttle flight 51-C of January 24, 1985, was launched during some of the coldest weather in Florida history. Upon examination of the booster joints, engineers at Thiokol noticed black soot and grease on the outside of the booster casing, caused by actual gas blow-by. This prompted Thiokol to study the effects of O-ring resiliency at low temperatures. They conducted laboratory tests of O-ring compression and resiliency between 50lF and 100lF. In July 1985, Morton Thiokol ordered new steel billets which would be used for a redesigned case field joint. At the time of the accident, these new billets were not ready for Thiokol, because they take many months to manufacture.

The Night Before the Launch

Temperatures for the next launch date were predicted to be in the low 20°s. This prompted Alan McDonald to ask his engineers at Thiokol to prepare a presentation on the effects of cold temperature on booster performance. A teleconference was scheduled the evening before the re-scheduled launch in order to discuss the low temperature performance of the boosters. This teleconference was held between engineers and management from Kennedy Space Center, Marshall Space Flight Center in Alabama, and Morton-Thiokol in Utah. Boisjoly and another engineer, Arnie Thompson, knew this would be another opportunity to express their concerns about the boosters, but they had only a short time to prepare their data for the presentation.1 Thiokol's engineers gave an hour-long presentation, presenting a convincing argument that the cold weather would exaggerate the problems of joint rotation and delayed O-ring seating. The lowest temperature experienced by the O-rings in any previous mission was 53°F, the January 24, 1985 flight. With a predicted ambient temperature of 26°F at launch, the O-rings were estimated to be at 29°F. After the technical presentation, Thiokol's Engineering Vice President Bob Lund presented the conclusions and recommendations. His main conclusion was that 53°F was the only low temperature data Thiokol had for the effects of cold on the operational boosters. The boosters had experienced O-ring erosion at this temperature. Since his engineers had no low temperature data below 53°F, they could not prove that it was unsafe to launch at lower temperatures. He read his recommendations and commented that the predicted temperatures for the morning's launch was outside the data base and NASA should delay the launch, so the ambient temperature could rise until the O-ring temperature was at least 53°F. This confused NASA managers because the booster design specifications called for booster operation as low as 31°F. (It later came out in the investigation that Thiokol understood that the 31°F limit temperature was for storage of the booster, and that the launch temperature limit was 40°F. Because of this, dynamic tests of the boosters had never been performed below 40°F.) Marshall's Solid Rocket Booster Project Manager, Larry Mulloy, commented that the data was inconclusive and challenged the engineers' logic. A heated debate went on for several minutes before Mulloy bypassed Lund and asked Joe Kilminster for his opinion. Kilminster was in management, although he had an extensive engineering background. By bypassing the engineers, Mulloy was calling for a middle-management decision, but Kilminster stood by his engineers. Several other managers at Marshall expressed their doubts about the recommendations, and finally Kilminster asked for a meeting off of the net, so Thiokol could review its data. Boisjoly and Thompson tried to convince their senior managers to stay with their original decision not to launch. A senior executive at Thiokol, Jerald Mason, commented that a management decision was required. The managers seemed to believe the O-rings could be eroded up to one third of their diameter and still seat properly, regardless of the temperature. The data presented to them showed no correlation between temperature and the blow-by gasses which eroded the O-rings in previous missions. According to testimony by Kilminster and Boisjoly, Mason finally turned to Bob Lund and said, "Take off your engineering hat and put on your management hat." Joe Kilminster wrote out the new recommendation and went back on line with the teleconference. The new recommendation stated that the cold was still a safety concern, but their people had found that the original data was indeed inconclusive and their "engineering assessment" was that launch was recommended, even though the engineers had no part in writing the new recommendation and refused to sign it. Alan McDonald, who was present with NASA management in Florida, was surprised to see the recommendation to launch and appealed to NASA management not to launch. NASA managers decided to approve the boosters for launch despite the fact that the predicted launch temperature was outside of their operational specifications.

The Launch

During the night, temperatures dropped to as low as 8°F, much lower than had been anticipated. In order to keep the water pipes in the launch platform from freezing, safety showers and fire hoses had been turned on. Some of this water had accumulated, and ice had formed all over the platform. There was some concern that the ice would fall off of the platform during launch and might damage the heat resistant tiles on the shuttle. The ice inspection team thought the situation was of great concern, but the launch director decided to go ahead with the countdown. Note that safety limitations on low temperature launching had to be waived and authorized by key personnel several times during the final countdown. These key personnel were not aware of the teleconference about the solid rocket boosters that had taken place the night before. At launch, the impact of ignition broke loose a shower of ice from the launch platform. Some of the ice struck the left-hand booster, and some ice was actually sucked into the booster nozzle itself by an aspiration effect. Although there was no evidence of any ice damage to the Orbiter itself, NASA analysis of the ice problem was wrong. The booster ignition transient started six hundredths of a second after the igniter fired. The aft field joint on the right-hand booster was the coldest spot on the booster: about 28°F. The booster's segmented steel casing ballooned and the joint rotated, expanding inward as it had on all other shuttle flights. The primary O-ring was too cold to seat properly, the cold-stiffened heat resistant putty that protected the rubber O-rings from the fuel collapsed, and gases at over 5000°F burned past both O-rings across seventy degrees of arc. Eight hundredths of a second after ignition, the shuttle lifted off. Engineering cameras focused on the right-hand booster showed about nine smoke puffs coming from the booster aft field joint. Before the shuttle cleared the tower, oxides from the burnt propellant temporarily sealed the field joint before flames could escape. Fifty-nine seconds into the flight, *Challenger* experienced the most violent wind shear ever encountered on a shuttle mission. The glassy oxides that sealed the field joint were shattered by the stresses of the wind shear, and within seconds flames from the field joint burned through the external fuel tank. Hundreds of tons of propellant ignited, tearing apart the shuttle. One hundred seconds into the flight, the last bit of telemetry data was transmitted from the *Challenger.*

Issues For Discussion

The *Challenger* disaster has several issues which are relevant to engineers. These issues raise many questions which may not have any definite answers, but can serve to heighten the awareness of engineers when faced with a similar situation. One of the most important issues deals with engineers who are placed in management positions. It is important that these managers not ignore their own engineering experience, or the expertise of their subordinate engineers. Often a manager, even if she has engineering experience, is not as up to date on current engineering practices as are the actual practicing engineers. She should keep this in mind when making any sort of decision that involves an understanding of technical matters. Another issue is the fact that managers encouraged launching due to the fact that there was insufficient low temperature data. Since there was not enough data available to make an informed decision, this was not, in their opinion, grounds for stopping a launch. This was a reversal in the thinking that went on in the early years of the space program, which discouraged launching until all the facts were known about a particular problem. This same reasoning can be traced back to an earlier phase in the shuttle program, when upper-level NASA management was alerted to problems in the booster design, yet did not halt the program until the problem was solved. To better understand the responsibility of the engineer, some key elements of the professional responsibilities of an engineer should be examined. This will be done from two perspectives: the implicit social contract between engineers and society, and the guidance of the codes of ethics of professional societies. As engineers test designs for ever-increasing speeds, loads, capacities and the like, they must always be aware of their obligation to society to protect the public welfare. After all, the public has provided engineers, through the tax base, with the means for obtaining an education and, through legislation, the means to license and regulate themselves. In return, engineers have a responsibility to protect the safety and well-being of the public in all of their professional efforts. This is part of the implicit social contract all engineers have agreed to when they accepted admission to an engineering college. The first canon in the ASME Code of Ethics urges engineers to "hold paramount the safety, health and welfare of the public in the performance of their professional duties." Every major engineering code of ethics reminds engineers of the importance of their responsibility to keep the safety and well being of the public at the top of their list of priorities. Although company loyalty is important, it must not be allowed to override the engineer's obligation to the public. Marcia Baron, in an excellent monograph on loyalty, states: "It is a sad fact about loyalty that it invites...single-mindedness. Single-minded pursuit of a goal is sometimes delightfully romantic, even a real inspiration. But it is hardly something to advocate to engineers, whose impact on the safety of the public is so very significant. Irresponsibility, whether caused by selfishness or by magnificently unselfish loyalty, can have most unfortunate consequences."

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Notes

1. "Challenger: A Major Malfunction." (see above) p. 194.

2. Baron, Marcia. *The Moral Status of Loyalty.* Illinois Institute of Technology: Center for the Study of Ethics in the Professions, 1984, p. 9. One of a series of monographs on applied ethics that deal specifically with the engineering profession. Provides arguments both for and against loyalty. 28 pages with notes and an annotated bibliography.

I. Introduction

In May of 1968, the Ford Motor Company, based upon a recommendation by then vice-president Lee Iacocca, decided to introduce a subcompact car and produce it domestically. In an effort to gain a large market share, the automobile was designed and developed on an accelerated schedule. During the first few years sales of the Pinto were excellent, but there was trouble on the horizon.

A. Grimshaw v. Ford Motor Company

In May 1972, Lily Gray was traveling with thirteen year old Richard Grimshaw in a 1972 Pinto when their car was struck by another car traveling approximately thirty miles per hour. The impact ignited a fire in the Pinto which killed Lily Gray and left Richard Grimshaw with devastating injuries. A judgment was rendered against Ford and the jury awarded the Gray family $560,000 and Matthew Grimshaw $2.5 million in compensatory damages. The surprise came when the jury awarded $125 million in punitive damages as well. This was subsequently reduced to $3.5 million.

B. The Criminal Case

Six month following the controversial Grirnshaw verdict, Ford was involved in yet another controversial case involving the Pinto. The automobile's fuel system design contributed (whether or not it was the sole cause is arguable) to the death of three women on August 10, 1918 when their car was hit by another vehicle traveling at a relatively low speed by a man driving with open beer bottles, marijuana, caffeine pills and capsules of "speed." The fact that Ford had chosen earlier not to upgrade the fuel system design became an issue of public debate as a result of this case. The debate was heightened because the prosecutor of Elkart County, Indiana chose to prosecute Ford for reckless homicide and criminal recklessness.

Some felt the issues raised in the Ford Pinto cases were an example of the "deep pocket" company disregarding consumer safety in pursuit of the almighty dollar. Others feel they are an example of runaway media coverage blowing a story out of proportion. Regardless of opinion, the Ford Pinto case is a tangled web of many complex legal and ethical issues.

To determine if the proper result was achieved in this case, one has to evaluate and weigh these many issues. The central issue in deciding whether Ford should be liable for electing not to redesign a defective product in order to maximize its bottom line, one must analyze the so-called "cost/benefit" analysis Ford used to defend this decision. Within the scope of this paper, this cost/benefit issue (and associated sub-issues) will be the focus of discussion. Other issues, such as the ethics involved in Ford's decision, the choice of prosecuting Ford criminally, whistle-blowing, the assignment of punitive damages and the Court of Appeals decision reducing the damages are all important issues of this case that will not be the focus herein.

II. Facts

A. Incident Facts

On August 10, 1978, three teenage girls stopped to refuel the 1973 Ford Pinto sedan they were driving. After filling up, the driver loosely reapplied the gas cap which subsequently fell off as they headed down U. S. Highway 33. Trying to retrieve the cap, the girls stopped in the right lane of the highway shoulder since there was no space on the highway for cars to safely pull off the roadway. Shortly thereafter, a van weighing over 400 pounds and modified with a rigid plank for a front bumper was traveling at fifty five miles an hour and stuck the stopped Pinto. The two passengers died at the scene when the car burst into flames. The driver was ejected and died shortly thereafter in the hospital. Inspecting the van shortly after the accident, the police found open beer bottles, marijuana and caffeine pills inside.

The subsequent proceedings were rather surprising. Based on the facts of the case, it seemed that any one of a number of parties could be liable in a civil action or prosecuted criminally. The obvious target seemed to be the driver of the van. It seems he could have been prosecuted for criminal homicide or the families of the victims could have pursued a civil action, in light of the fact the driver possessed several controlled substances at the time of the accident.

A second potential party open to a civil suit was the Indiana Highway department. It was their design which left no safe stopping place along Highway 33 where cars could pull over for emergencies. In fact, the road was so dangerous that the Elkart County Citizens' Safety Committee had previously written a letter to the department asking that the road design be modified to provide safe stopping place for emergencies. It is also conceivable, the driver of the Pinto could have been found negligent for stopping a car in the middle of the highway.

The first surprise of the resulting litigation carne when Indiana state prosecutor filed suit against Ford Motor Company for criminal recklessness and reckless homicide. The famous and highly publicized legal battle was underway. Some have argued the prosecution acted unethically from day one, gathering and hiding evidence from the defendant and concealing information about the condition of the van driver. Whether true or not, the following litigation caused damage that would take Ford years to recover from.

B. Questionable Design

The controversy surrounding the Ford Pinto concerned the placement of the automobile's fuel tank. It was located behind the rear axle, instead of above it. This was initially done in an effort to create more trunk space. The problem with this design, which later became evident, was that it made the Pinto more vulnerable to a rear-end collision. This vulnerability was enhanced by other features of the car. The gas tank and the rear axle were separated by only nine inches. There were also bolts that were positioned in a manner that threatened the gas tank. Finally, the fuel filler pipe design resulted in a higher probability that it would to disconnect from the tank in the event of an accident than usual, causing gas spillage that could lead to dangerous fires. Because of these numerous design flaws, the Pinto became the center of public debate.

These design problems were first brought to the public's attention in an August 1977 article in Mother Jones magazine. This article condemned the Ford Motor Company and the author was later given a Pulitzer Prize. This article originated the public debate over the risk/benefit analysis used by the Ford Motor Company in their determination as to whether or, not the design of the Pinto fuel tank be altered to reduce the risk of fire as the result of a collision.

The crux of the public debate about The Ford Motor Company was the decision not to make improvements to the gas tank of the Pinto after completion of the risk/benefit analysis. Internal Ford documents revealed Ford had developed the technology to make improvements to the design of the Pinto that would dramatically decrease the chance of a Pinto "igniting" after a rear-end collision. This technology would have greatly reduced the chances of burn injuries and deaths after a collision. Ford estimated the cost to make this production adjustment to the Pinto would have been $11 per vehicle. Most people found it reprehensible that Ford determined that the $11 cost per automobile was too high and opted not to make the production change to the Pinto model.

C. Risk/Benefit Analysis

In determining whether or not to make the production change, the Ford Motor Company defended itself by contending that it used a risk/benefit analysis. Ford stated that its reason for using a risk/benefit analysis was that the National Highway Traffic Safety Administration (NHTSA) required them to do so.

The risk/benefit approach excuses a defendant if the monetary costs of making a production change are greater than the "societal benefit" of that change. This analysis follows the same line of reasoning as the negligence standard developed by Judge Learned Hand in United States vs. Carroll Towing in 1947 (to be discussed later). The philosophy behind risk/benefit analysis promotes the goal of allocative efficiency. The problem that arose in the Ford Pinto and many other similar cases highlights the human and emotional circumstances behind the numbers which are not factored in the risk/benefit analysis.

The Ford Motor Company contended that by strictly following the typical approach to risk,/benefit analysis, they were justified in not making the production change to the Pinto model. Assuming the numbers employed in their analysis were correct, Ford seemed to be justified. The estimated cost for the production change was $11 per vehicle. This $11 per unit cost applied to 11 million cars and 1.5 million trucks results in an overall cost of $137 million.

The controversial numbers were those Ford used for the "benefit" half of the equation. It was estimated that making the change would result in a total of 180 less burn deaths, 180 less serious burn injuries, and 2,100 less burned vehicles. These estimates were multiplied by the unit cost figured by the National Highway Traffic Safety Administration. These figures were $200,000 per death, $67,000 per injury, and $700 per vehicle equating to the total "societal benefit" is $49.5 million. Since the benefit of $49.5 million was much less than the cost of $137 million, Ford felt justified in its decision not to alter the product design. The risk,/benefit results indicate that it is acceptable for 180 people to die and 180 people to burn if it costs $11 per vehicle to prevent such casualty rates. On a case by case basis, the argument seems unjustifiable, but looking at the bigger picture complicates the issue and strengthens the risk/benefit analysis logic.

III. History and Development of Product Liability

A. Introduction

When defendants were found liable for only intentional harms, these harms fell under the category of absolute liability. Over time, courts added liability to some accidental harms. In order for a court to determine there was no liability in a conflict, it had to be ascertained whether or not the accident was "truly unavoidable." Technological advances created societal harms that were never before contemplated by courts. The truly unavoidable standard became a grayer area that was undefined and unreliable. Eventually, as industry rapidly advanced further, it became impossible and unreasonable to describe any accident as unavoidable. Still, courts seemed unwilling to shift to the theory of absolute liability, as it seemed to strict. However, with the courts finding fewer and fewer harms "unavoidable", another level had to be found between unavoidable accidents and strict liability.

B. The Ordinary Care Standard

In the mid 1800s, courts began the evolution of moving away from what they once considered an important decision--whether a harm was a result of an action "on trespass" or a harm as a result of an action "on the case." The first landmark decision moving away from this distinction and thinking was Brown v. Kendall in 1850. In the decision, Chief Justice Shaw acknowledged moving away from this traditional distinction and to consideration of whether a harm was "willful, intentional, or careless." Not only did this decision move away from the strict "all or nothing" standard, it established the fluctuating standard of "ordinary care." Judge Shaw explained the use of this new standard:

"In using this term, ordinary care, it may be proper to state that what constitutes ordinary care will vary with the circumstances of cases. In general, it means that kind and degree of care, which prudent and cautious men would use, such as required by the exigency of the case, and such as is necessary to guard against probable danger."

In essence Judge Shaw had created a "moving" standard of negligence that varied from situation to situation depending on the extent of care used, rather than the inflexible extremes discussed above. This new standard was not just a flat decision of whether an actor used due care in a situation, but whether the actor should have recognized the danger before taking the risk. Courts also required a defendant's actions be related to the harm incurred. In Crain v. Petrie, the court stated that "damages must appear to be the legal and natural consequences arising from the tort. Courts also considered whether the defendant should have taken some kind of preventive measure in advance that could have foreseeable prevented the harm.

These many factors the court considered boiled down into one main question: Was the accident truly avoidable or the fault of the defendant? The Brown court stated,

"If, then, in doing this act, using due care and all proper precautions necessary to the exigency of the case, to avoid the hurt to others, in raising his stick..., he accidentally hit the plaintiff in his eye and wounded him, this was the result of the pure accident, or was *involuntary,* and *unavoidable,* and therefore the action would not lie.
This thinking was followed in similar cases and decisions of the time. As stated above, this thinking moved the court from cut-and-dried ideas of negligence to ones that fluctuated and had to be examined on a case by case basis. If an accident seemed to be unavoidable and part of every day life there would be no action for recovery.

As technology progressed, courts began to find less and less accidents "unavoidable." In Huntress v. Boston & Main R.R., the court found the defendant negligent even though it took all necessary precautions. When a pedestrian was killed walking across the railroad tracks and the locomotive engineer had used all possible precautions in conducting the train, the defendant was still found to be negligent. The court stated that the railroad company should have foreseen the plaintiff's poor appreciation of the risk and that whether more precautions were necessary was a question for the jury. As the power of design and invention advanced, so did the courts' perception of the power to prevent accidents. It seemed the courts had almost moved to the extreme of absolute liability.

With this evolution, the courts were faced with a new problem. Should defendants be found liable in almost every situation because of new technological 'advancements? This created a new theory of negligence, one of balancing risks and benefits. In the early 1900s the courts evolved from just determining if an accident were unavoidable (as most at this point were considered to be) to what the costs were to avoid this accident in some fashion. The first attempt to consider this question and create a new standard was in a 1919 case, Adams v. Bullock.

In Adams, a young boy was playing with a rod when it struck the defendant's trolley wires that had been strung under a railroad bridge where the boy was walking. The court reversed a judgment for the plaintiff, claiming that the company had taken all reasonable precautions to avoid the accident. Judge Cardozo's opinion made use of the traditional analysis and verbiage of the avoidable/unavoidable analysis. However, he discussed the "duty to adopt all reasonable precautions. Furthermore, Judge Cardozo stated that the defendant had acted with the area of normal provision.

C. The Introduction of the Balancing Approach

Although Judge Cardozo concluded that the accident was not foreseeable and therefore unavoidable, the Adams case laid the groundwork for a "balancing" approach to negligence. The balancing approach assumes that if an accident has a very low probability, and there is a cost associated with preventing it, a defendant is not liable if he does not take precautionary measures. By stating that absent a "gift of prophecy the defendant could not have predicted the point upon the route where such an accident would occur," Judge Cardozo indicated that giving every possibility the ultimate amount of protection would be too costly compared to the risk of injury. He further stated that guards everywhere would have prevented the injury but this would prove to be much too costly, and "guards here and there are of little value. This decision was the harbinger of the balancing standard and cost/benefit analysis; a weighing of the risk of harm and the overall costs of avoiding it.

At the turn of the century, courts began focusing on this "balancing" method to determine liability. Costs, risks, and probability began to make their way into decisions. Courts began to compare degrees of risks and costs of harms with the benefits of activities on society. The trend moved toward placing the burden on society in instances where the benefit outweighed the risk or the risk was less than the cost to avoid it. In cases such as this, the ``risk initiator" was assigned no liability. This balancing act seemed to be a tolerable middle ground between the old negligence liability standard and the extreme standard of absolute liability.

With courts struggling to define the middle ground during this time of technological advancement, they faced the same questions legal systems faced in similar times such as the industrial revolution and the growth of railroads. As the advancements created new products and the profits that went with them, courts had to decide what levels of risk society could tolerate and who should bear the costs when harms actually occurred.

D. The "BPL" Formula

With the evolution of the negligence standard incorporating risks and costs, courts sought a middle ground that would not leave defendants open for unreasonable liability suits but which also would not leave victims uncompensated when damages had occurred. In the 1947 decision of <u>United States v. Carroll Towing Co.,</u> Judge Learned Hand boiled the theory of negligence down to an algebraic equation. In <u>Carroll Towing</u>, a barge named the "Anna C" was tied up to a pier along with a flotilla of other barges. A tug, the "Carroll," owned by the Carroll Towing Company attempted to move from one barge in the same area to another. During this time, the "Anna C" broke away from the pier and floated down the river where it collided with a tanker and sank. Since there was no bargee on board the "Anna C," no one informed the "Carroll" that the "Anna C" was leaking. Because of this, the "Anna C" sank and its cargo was lost. Under admiralty law, if the defendants could prove that plaintiff's negligence contributed to the loss, they would be excused from paying a portion of the damage. The defendant's argument was based on the fact that since there was no bargee present, the plaintiff was also liable. However, there was no general rule as to whether the presence of a bargee would make the owner of the barge liable for lost cargo and injuries to other boats.

Judge Hand attempted to quantify a criteria to determine when leaving a barge unattended was negligence and when it was not. He decided that this would be determined by a weighing of the factors discussed above. Judge Hand transformed the "balancing act" utilized in prior decisions. In his opinion, he wrote:
"Since there are occasions when every vessel will break from her moorings, and since, if she does, she becomes a menace to those about her; the owner's duty, as in other similar situations, to provide against resulting injuries is a function of three variables: (1) The probability that she will break away; (2) the gravity of the resulting injury, if she does; (3) the burden of adequate precautions. Possibly it serves to bring this notion into relief to state it.in algebraic terms: if the probability be called P; the injury, and the burden, B; liability depends upon whether B is less than L multiplied by P."

Under the theory that Judge Hand developed in <u>Carroll</u>, a party is found negligent and liable for the damages resulting from his actions if B<PL. "B," the burden of adequate precautions, is the accident

avoidance cost. "P" is the probability the defendant's actions will result in an accident. "L" is the cost of that accident if it did occur. "PL" is the risk of the activity, the expected liability of the discounted accident cost. The negligence standard had been formalized into algebraic terms. If the expected harm exceeded the cost to take precaution, the defendant was obligated to take the precaution, and if they did not, would be held liable. If the cost was larger than the expected harm, the defendant was not expected to take the precaution. If there was an accident, he was not found liable. Based on the facts of Carroll Towing, the defendant was found liable. Judge Hand felt the expected harm (the probability of the accident, multiplied by the cost of the accident) was greater than the justification for a one and a half day absence of a bargee.

E. Risk/Utility Analysis

Risk/utility analysis then developed out of the same balancing reasoning, applied to determine liability in the area of product design. In these types of cases, courts must determine whether a manufacturer should be held liable if goods are "imperfect" as a result of production or distribution. In past cases, courts had difficulty in this area. In Greenman v. Yuba Power Products, Inc., a 1963 case, the court stated that the defendant was not able to see the possibility for injury until after the injury occurred and by traditional negligence standards should be found not liable. This type of conclusion troubled the courts, since the burden on the plaintiff seemed almost insurmountable.

There were a number of reasons why this type of finding was unfair. First and foremost, companies' manufacturing operations are the party in control of the product from its inception. Manufacturing divisions have a chance to monitor design and distribution and therefore seems the logical party to be held liable if the design of its product leads to an injury. However, it seems illogical for the consumer to bear the burden of a harm it had absolutely no control over. Also, requiring manufacturers to be liable for their products makes them take more precautionary measures, the cost of which can be spread out in the price of its products to the consumers who make use of them. The problem was the same, however. Where is the middle ground between the earlier standard and absolute liability and how is it defined?

The first step in finding this middle ground in manufacturing liability cases was to remove requirements of warranty and privity of contract that manufacturers used to escape liability in the past. In Greenman, the court stated that removing the obstacles earlier set by warranty law put manufacturer's liability in the correct realm. This area was "not one governed by the law of contract warranties but by the law of strict liability in tort ... A manufacturer is strictly liable in tort when an article he places in the market... proves to have a defect that causes injury to a human being." The obvious question therefore was, what is a "defective product"?

The definition provided by section 402A of the Second Restatement of Torts assigned strict liability to products with "a condition not contemplated by the ultimate consumer, which will be unreasonably dangerous to him ... Many products cannot possibly be made entirely safe for all consumption, and any food or drug necessarily involves some harm, if only from overcomsumption." Obviously, there was intended to be some leeway short of strict liability for manufacturers, but there was still no clear answer as to what was defective and what was not.

Attempting to end the frustration and quantify "defective product," courts started to turn to a risk-utility balancing similar to Judge Learned Hand's "BPL Formula." This evolved into a balancing of the benefits of the product against the risks and the cost of avoidance. In Caterpillar Tractor Co. v. Beck, the court stated the jury could be instructed a product is defectively designed if "the plaintiff proves that the product's design proximately caused injury and the defendant fails to prove in the light of relevant factors, *that on balance the benefits of the challenged design outweigh the risk of the danger inherit in .such design."* In Turner v. General Motors Corp, the court stated that "a defectively designed product is one that is unreasonably dangerous as designed, *taking into consideration the utility of the product and the risk involved in its use.*"

After long debate, the courts have settled upon this risk/benefit analysis. For a defendant to be found liable, its product must be determined to be defective. A defect can take three forms: a defect in design (as was alleged against the Ford Motor Company), a defect in manufacture, or a defect in warning. In Ford's case, if the design is found to be defective, the company would be held liable. The question remains, what makes a design defective?

While not stated neatly in algebraic terms, such as in the BPL analysis, this entails a balancing of utility and risks. This standard is not easily quantified and must be decided on a case-by-case basis by juries. They must decide in each instance whether the risks associated with the product are reasonable for society to absorb given the benefits of the product. Therefore, the duty of the jury is not to decide whether the conduct of the manufacturer is reasonable, but whether the product, after the full ramifications are revealed, is reasonable. The difference is that risk/utility analysis requires a determination of the costs, risks and benefits of society's use of the product as a whole, while the 13PL cost/benefit analysis entailed determining the costs and benefits of preventing the particular accident. In the end, the risk-utility's primary duty is to establish a threshold of acceptable risk that every good must equal or exceed, a threshold that can rise with changing social and commercial experience. This leads to a economically efficient use of resources and overall wealth maximization.

F. Ford's Risk/Benefit Analysis

The main controversy surrounding the Ford Pinto case was The Ford Motor Company's choices made during development to compromise safety for efficiency and profit maximization. More specifically, it was Ford's decision to use the cost/benefit analysis detailed in section 11 to make production decisions that translated into lost lives. During the initial production and testing phase, Ford set "limits for 2000" for the Pinto. That meant the car was not to exceed $2000 in cost or 2000 pounds in weight. This set tough limitations on the production team. After the basic design was complete, crash testing was begun. The results of crash testing revealed that when struck from the rear at speeds of 31 miles per hour or above, the Pinto's gas tank ruptured. The tank was positioned according to the industry standard at the time (between the rear bumper and the rear axle), but studs protruding from the rear axle would puncture the gas tank. Upon impact, the fuel filler neck would break, resulting in spilled gasoline. The Pinto basically turned into a death trap. Ford crash tested a total of eleven automobiles and eight resulted in potentially catastrophic situations. The only three that survived had their gas tanks modified prior to testing.

Ford was not in violation of the law in any way and had to make the decision whether to incur a cost to fix the obvious problem internally. There were several options for fuel system redesign. The option most seriously considered would have cost the Ford Motor Company and additional $11 per vehicle. Under the strict $2000 budget restriction, even this nominal cost seemed large. In addition, Ford had earlier based an advertising campaign on safety which failed miserably. Therefore, there was a corporate belief, attributed to Lee Iacocca himself, of "safety doesn't sell."

Ultimately, the Ford Motor Company rejected the product design change. This was based on the cost-benefit analysis performed by Ford (see Exhibit One). Using the NHTSA provided figure of $200,000 for the "cost to society" for each estimated fatality, and $11 for the production cost per vehicle, the analysis seemed straightforward. The projected costs to the company for design production change were $137 million compared to the project benefits of making the design change which were approximately $49.5 million. Using the standard cost/benefit analysis, the answer was obvious--no production changes were to be made.

Exhibit One: Ford's Cost/Benefit Analysis
Benefits and Costs Relating to Fuel Leakage
Associated with the Static Rollover
Test Portion of FMVSS 208

Benefits

Savings: 180 burn deaths, 180 serious burn injuries, 2100 burned vehicles
Unit Cost: $200,000 per death, $67,000 per injury, $700 per vehicle
Total Benefit: 180 x ($200,000) + 180 x ($67,000) + 2100 x ($700) = **$49.5 Million**

Costs

Sales: 11 million cars, 1.5 million light trucks
Unit Cost: $11 per car, $11 per truck
Total Cost: 11,000,000 x ($11) + 1,500,000 x ($ I 1) = **$137 Million**

From Ford Motor Company internal memorandum: "Fatalities Associated with Crash-Induced Fuel Leakage and Fires." Source: Douglas Birsch and John H. Fielder, THE FORD PINTO CASE: A STUDY IN APPLIED ETHICS. BUSINESS, AND TECHNOLOGY. p. 28.1994.

IV. The Negligence Efficiency Argument

A. Ford's Decision

The Ford Motor Company's use of the risk/benefit analysis was the central issue of the suits filed against the company. Many pieces of evidence, including a number of internal Ford documents indicate the risk/benefit analysis was the main reason for Ford's decision not to make design changes to increase vehicle safety. However, before discussion of the risk/benefit analysis it should be noted there were secondary concerns which supported Ford's decision not to upgrade the fuel system design: (1) As stated above, Ford had based an earlier advertising campaign around safety, which failed. The company realized this was not a primary factor in car sales; (2) the bad publicity involved with a recall would be too much negative publicity to overcome. If this unquantifiable factor were included in the cost/benefit analysis the difference may have been overwhelming. Even though it was not a factor included in the analysis, Ford wanted to avoid it at any cost; (3) At the time of the product design and crash tests, the law did not require them to redesign the fuel system; and, (4) It was customary in the automotive industry to place the gas tank and between the rear axle and bumper.

Although case law has shown that business custom is not an excuse to escape liability, custom combined with the risk/benefit analysis would lead to the same result. With these factors influencing the decision in the background, the primary factor was Ford's risk/benefit analysis of making the changes. The question is: Should a risk/benefit analysis be used in all circumstances, and was it the proper framework to use in this situation? If so, it seems that the correct decision was made. Examining this question after-the-fact, it certainly seems like a poor decision.

B. The Numbers

The Ford Motor Company's risk/benefit analysis indicated costs would be 2.5 times larger than the resulting benefits. It is apparent why Ford chose no to go ahead with the fuel tank adjustment. However, basing this decision on just the numbers with no consideration of any other factors falls short of a comprehensive analysis of the action. chose not to go ahead with the fuel tank adjustment. To do a complete job of analyzing Ford's decision, the variables inside the equation must be examined. On the cost side of the equation, the most questioned variable during the case was the cost per vehicle used by Ford. The manufacturer claimed making adequate changes to the fuel system would have cost $11 per vehicle. Some evidence indicated that these potential costs may have been much lower, maybe as low as $5 per vehicle. Even with this lower cost and all other factors remaining the same, the costs still would have exceeded the benefits, although the difference would have been much less substantial (see Exhibit 2). In fact, will all other variables remaining the same, the cost per vehicle would have had to be as low as $3.96 to make the benefits "break even" with the costs (see Exhibit 3). However, if the costs were around $5 per vehicle, the Ford Motor Company would not have had as strong a risk/benefit argument as with the $11 figure provided.

Exhibit Two: Ford's Cost/Benefit Analysis at
$5.08 Per Fuel Tank Replacement

Benefits

Savings: 180 burn deaths, *180* serious burn injuries, 2100 burned vehicles
Unit Cost: $200,000 per death, $67,000 per injury, $700 per vehicle
Total Benefit: 180 x ($2,00,000) + 180 x ($67,000) + 2100 x ($700)= **$49.5 Million**

Costs

Sales: 11 million cars, 1.5 million light trucks
Unit Cost: $5.08 per car, *$5.08* per truck
Total Cost: 11,000,000 x ($5.08) + 1,500,000 x ($5.08) = ***$63.5*** **Million**

Exhibit Three: The Break Even Point of the Cost/Benefit Analysis

<u>Benefits</u>

Savings: 180 burn deaths, *180* serious burn injuries, 2100 burned vehicles
Unit Cost: $200,000 per death, $67,000 per injury, $700 per vehicle
Total Benefit: 180 x ($200,000) + 180 x ($67,000) + 2100 *x* ($700) = **$49.5 Million**

<u>Costs</u>

*Sales:*11 million cars, 1.5 million light trucks
Unit Cost: $5.08 per car, *$5.08* per truck
Total Cost: 11,000,000 x ($3.96) + 1,500,000 *x* ($3.96) = **$49.5 Million**
Therefore, if the cost to replace the fuel tank was $3.96 per vehicle, the costs and benefits would equal each other out (all other things remaining the same).

The "benefit side" of the equation contains the most controversial number of the analysis--the value of a human life. Ford estimated no alterations to the gas tank design would result in 180 deaths, 180 burn victims and 2100 burned vehicles. In retrospect, these estimates are slightly low. It is hard to determine the exact number of victims because every victim did not file a claim, but these numbers were reasonable estimations at the time. Ford used $200,000 as the "cost" or "lost benefit" for each fatal burn injury, 567,000 for each burn injury and $700 for each burned vehicle. The number quantifying the price of a value life ($200,000) is what makes this problem so difficult. It is hard to decide what a life is worth, but most people feel the value of theirs is greater than $200,000. While this $200,000 figure was the most controversial of the equation, it was not determined by Ford. In 1972, the National Highway Traffic Safety Administration (NHTSA) provided the auto industry with the number $200,725 as the value to be utilized in risk/ benefit analysis such as was done by Ford (see Exhibit 4).

Exhibit Four: What is a Life Worth?
Societal Cost Components for Fatalities
1972 NHTSA Study

Component	**1971 Costs**
Future Productivity Losses	
Direct	$132,000
Indirect	41,300
Medical Costs	
Hospital	700
Other	425
Property Damage	1,500
Insurance Administration	4,700
Legal and Court	3,000
Employer Losses	1,000
Victim's Pain and Suffering	10,000
Funeral	900
Assets (Lost Consumption)	5,000
Miscellaneous	200
Total Per Fatality	**$200,725**

Source: Douglas Birsch and John H. Fielder, THE FORD PINTO CASE: A STUDY IN APPLIED ETHICS, BUSINESS. AND TECHNOLOGY, p. 26, 1994.

Following the standard for negligence established by Judge Learned Hand in Carroll Towing, or the risk/utility standard established for manufacturer's liability, the decision was well founded. The costs to Ford to make this change, which would have been borne by the consumer, was 2.5 times higher (using the original numbers) than the benefit to society. Some negative publicity may have been expected, but certainly Ford did not anticipate being found criminally negligent. In fact, it would seem Ford had a strong argument against any liability whatsoever. The decision in the liability suit with the award of punitive damages was a surprise to the Ford Motor Company, much less the criminal prosecution. How could such a decision be rendered after Ford Motor Company had followed the standard set by the courts themselves? The answer lies in the fact that the "benefit" side of the equation included the benefit of saving lives, and putting a value on this variable is not as defensible as putting a value on the benefit of saving an inanimate object, such as a vehicle.

V. The Negligence-Efficiency Debate

A. Introduction

The Ford Motor case has spurned the arguments for and against the use of risk/benefit analysis because of its foundation of economic efficiency. The Ford Motor Company case has spurred this argument. In 1972, Judge Richard Posner's article on the negligence-efficiency theory seemed to be the "starting point" for this argument and was both highly praised and highly criticized. The essence of this article is summarized in the following excerpt: "We lack a theory to explain the social function of the negligence concept ... This article attempts to formulate and test such a theory.... The essential clue, I believe, is provided by Judge Learned Hand's famous formulation of the negligence standard.... In a negligence case, Hand said, the judge (or jury) should attempt to measure three things: the magnitude of the loss if an accident occurs; the probability of the accident's occurring; and the burden of taking precautions that would avert it. If the product of the first two terms exceeds the burden of precautions, the failure to take those precautions is negligence. Hand was adumbrating, perhaps unwittingly, an economic meaning of negligence.... If the cost of safety measures.... exceeds the benefit in accident avoidance to be gained by incurring that cost, society would be better off, in economic terms, to forego accident prevention.... Furthermore, overall economic value or welfare would be diminished ... by incurring a higher accident-prevention cost to avoid a lower accident cost.''

Thus, the economic efficiency of negligence argument was born. While many economists have agreed and praised this article, it has been equally criticized by those not taking the "economic point of view." I will first discuss some of the many arguments against this economic efficiency point of view in light of the Ford Pinto case. Following is a further elaboration of Posner's view and defense of his position.

B. Arguments Against Negligence-Efficiency

1. Ethics

Taking an ethical approach to the Ford Pinto case makes accepting the risk/benefit analysis performed by the Ford Motor Company difficult. In making what seems to be the correct decision based on numbers, Ford is essence adopted a policy of allowing a certain number of people to die or be injured even though they could have prevented it. When taken on a case-by-case basis the decision seems to be a blatant disregard for human life. From a human rights perspective, Ford disregarded the injured individual's rights and therefore, in making the decision not to make adjustments to the fuel system, acted unethicallv.

2. Act Utilitarianism

A second problem with strictly applying the risk/benefit framework is that it does not seem to take into account all of the consequences of Ford's decision. This position is considered the "act utilitarian' point of view. The act utilitarian approach evaluates each action separately and the consequences that arise from it. This analysis would include any "harms" or "benefits" incurred by any people involved in the case. In utilizing this approach, it seems there are many factors that the Ford Motor Company did not account for in its risk/benefit analysis. When taking the situation from this perspective, it seems like the harms of not changing the fuel system outweighed the benefits. Not included in the previous risk/benefit analysis was the millions of dollars in settlements in unreported cases that never saw the courtroom. It is almost a sure bet that the settlement numbers were more on a per-case basis than the average numbers used for lost life per accident. Also, the bad publicity and reputational damage suffered by Ford over the next few years for being the cause of these lawsuits is hard to quantify, but the harm was considerable. >From the utilitarian point of view, the harms and the benefits are far closer together than Ford determined in its analysis. In addition, if this was figured after-the-fact the harms far outweighed the benefits. This would be due to the cost of having to recall the 19711976

Pintos after the fact and the extreme bad publicity (much worse than could have been expected) that the Ford Motor Company suffered through for years after all litigation was settled.

3. Health and Safety Regulation Exception

Critics argue there are several other related, yet distinct reasons why the Ford Motor company, as well other companies finding themselves in similar positions, should be condemned for relying on a risk/benefit analysis to make decisions based on consumer safety. In the areas of safety and health regulation, there are instances where it may not be wise to undertake a certain decision even though the benefits do not outweigh the costs. This idea is imbedded somewhere between the utilitarian point of view and ethical point of view, discussed above. That is, the issue of whether the benefits outweigh the costs should not govern our moral judgment. There are some cases where a company must "do the right thing." While this may seem an argument based on emotion, there seem to be certain instances where these kind of considerations must be made. For instance, when governmental officials decide what level of pollution is allowable they take into effect certain vulnerable people--such as asthmatics or the elderly--and set the standard higher although the average citizen would not be affected by a lower one. This decision escapes the risk/benefit analysis. The higher standard is set so that the rights of the minority are not sacrificed for the needs of the majority. This kind of decision, much like automobile safety, are in the realm of specially valued things. For these, many will argue, risk/benefit analysis should not apply.

4. Expressing Terms in Dollar Values

In order to perform a risk/benefit analysis, all costs and benefits must be expressed in some common measure. This measure is typically in dollars, as the Ford Motor Company used in its analysis. This can prove difficult for things that are not commonly bought and sold on the open market. This is mainly the case for environmental policy, such as permissible levels of air pollutants, as in the example above. The Ford Pinto case provides an extreme example. It questions how to value human life.

Economists have attempted to quantify, non-quantifiable items using varying methods with varying success. Since individuals have unique tastes and values they are willing to pay different amounts for products and resources. This valuation system often receives high criticism. People's willingness to pay for something can also vary widely depending upon other circumstances. Based on these reasons, attempts to quantify something such as a human life can be very difficult and is the most debated aspect of the Ford Pinto case.
There are numerous things which individuals consider "priceless." For instance, most people would claim that they would not sell their right to vote or their freedom of speech for any amount of money. Therefore, to tell someone that there is a certain price for their life is a preposterous notion. Therefore when taken on a case-by-case basis it is impossible for an individual to grasp the concept. There are numerous things which individuals consider "priceless." For instance, most people would claim that they would not sell their right to vote or their freedom of speech for any amount of money. Moreover, would a parent be able to put a value on the life of a child? Obviously, the notion that, on an individual basis, a person would take a certain amount of money for their life is ludicrous. To tell someone that $200,725 is a sufficient trade-off for their life, as argued in the Ford Pinto case, illustrates this point. Economists, however, do not agree with the "priceless" concept. To them, to trade one unit of anything, even a life, for an infinite quantity of all other goods is an equally preposterous notion. It can be argued

that everything can be priced or have a value laid upon it. To take this theory down to an individual level reduces the strength of this notion.

In Ford's case, the $200,725 value of a human life was provided to the company by the National Highway Traffic Safety Administration. The criticism for the value can not be laid upon Ford. The criticism is in using a number, or in other words using the risk/benefit analysis, in this situation at all. To compound the problem, Ford seemed to blindly follow the dictated numbers without giving any extra consideration to the fact that it in fact was a human life they were quantifying.

5. No Wealth Maximization

Related to the lack of "markets" or "prices" for a life is the idea of wealth maximization. The foundation of the risk/benefit analysis is the theory of economic efficiency and an underlying principle for efficiency is wealth maximization. If legal decisions are based on efficiency, then nothing will be wasted and the wealth of the country will be at its maximum. However, in order to conduct an efficiency analysis, everything must have a price--returning to the reoccurring problem. Since the reliance on prices is necessary and not merely contingent, the system of wealth maximization cannot tell us anything about right conduct where no prices exist. Prices are, in part, the result of demand and demand is the result of prior entitlements. Consequently, wealth maximization cannot generate an initial set of entitlements." Along the same lines, efficiency theory assumes that wealth maximization is the goal of law, which is not the case. The goal of law is the indefinable term. "justice." Judges and juries do not attempt to make decisions based on wealth maximization, they base their decisions on justice. This difference can be seen in the special rules for rescue, handicapped citizens, and whether the insane are found liable for their torts.

6. Externalities

Another potential problem with the risk,/benefit approach is the fact that it does not take externalities into effect. This is a topic with which the law of torts often has trouble. However, it cannot be ignored just because it is hard to compute. Victims are permitted to recover for pain and suffering and the cost/benefit analysis seems to ignore this point. It is yet another one of the variables that is almost impossible to estimate, much less pinpoint. In addition, this is another area where the lack of a market is influential. Minimization of social costs differs from the minimization of private costs precisely because there is an absence of complete markets, and this absence is exactly what makes measurements so difficult.

7. Activity Frequency

If a company or a court were to accurately analyze the costs and benefits of an activity, it must calculate the number of times the potential victim engages in the activity. Taking out the number of times the activity is engaged in reduces the damages. This calculation is often unobtainable, especially in Ford's case in terms of automobile use. Professor Polinsky, in his book, An Introduction to Law and Economics explains, "In practice it is usually not feasible to include the level of participation in the activity has an aspect of the standard of care. For example, it would be virtually impossible for a court to determine bow many miles a particular person drives each. year since that person might drive a different car that is shared with other family members or he might drive different cars owned by the household. If the injurer's level of participation in the activity is omitted from the standard of care, than a negligence rule generally will lead him to participate in the activity to an excess degree. The reason for this is straightforward, if the care he exercises meets the standard of care, be will not be liable for any damages. In practice, the negligence rule is likely to be inefficient for this reason.

8. Negligence is Predictable: Victims Often Lose

Finally, the cost/benefit analysis and economic efficiency reasoning is argued to be a skewed framework because it does not take into account the fact that injured parties are at a disadvantage. While the law attempts to place the plaintiff and defendant on equal ground, it is impossible to accomplish. The plaintiff must prove the negligence, a difficult task. The negligence-efficiency theory does not account for plaintiffs who cannot afford to bring a lawsuit to trial or those who cannot establish negligence although it exists. With the adoption of the negligence-efficiency theory, it is predictable that victims are going to lose more than. They are going to win.

9. Conclusion

Obviously there are a number of arguments against the use of cost/benefit analysis and the negligence-efficiency theory. Most of these arguments are separate but related and .revolve around the fact that there are no markets or prices for human life. It will be forever debated whether it is possible to set a price or value on a life to use in these calculations and whether this leads to an economically efficient outcome In the case of Grimshaw, the jury was obviously appalled with Ford's attempt to apply the NHTSA's calculation to risk/benefit standard. Was this a sign of this standard's inefficiency or was it just a sign of an ineffective jury?

C. For Negligence-Efficiency

For as many arguments as there are against risk/benefit analysis, there are as many claiming it is economically efficient and therefore the correct standard. In defense of the Ford Motor Company, this standard developed over many years of caselaw, as detailed earlier in this paper. This negligence standard and the use of risk/benefit analysis for product liability had been accepted by courts for years before the Pinto controversy. There was no reason for Ford to believe that this was not the standard that should be used in making its decision. Ford's automatic decision once it "ran the numbers" confirms the fact that they did not question the idea of using this analysis. In addition, there are many arguments in support of this sort of analysis other than just the fact that this was the standard at the time.

1. Risk/benefit Analysis is "Instinctively Done"

In 1972, Judge Richard Posner wrote an article entitled, "A Theory of Negligence," claiming all tort law furthers economic efficiency. He claims that while judges do not write opinions in terms of welfare economics, there has always been an effort to decide cases on this basis. "People can apply the principles of economics intuitively--and thus `do' economics without knowing they are doing it.'' Therefore, Posner claims that the Carroll Towing decision was not a novel concept, it just expressed in algebraic terms what court had long been applying.

2. Maximization of Social Resources

For defendants, such as the Ford Motor Company, who create risks of harm that may be suffered by others, the risk-benefit standard for negligence provides incentives to take precautions to avoid or minimize risks that can be avoided more cheaply than the cost of the precautions. By holding a defendant liable for injuries that could have been avoided at less cost than the accident, a risk-benefit test acts as a deterrent to curb risks that are worth avoiding, while allowing a defendant to take actions or avoid precautions that are not worth deterring. Deterring conduct that results in greater accident costs than the benefits of the conduct minimizes the total costs of accidents and accident precaution. Therefore, it seems this tort "policy" serves the goal of maximizing societal resources.

To understand the efficiency theory of the risk-benefits analysis, one other point must be explained. In a products liability design defects case, use of the discussed liability standard requires identification of an alternative design that would have prevented the accident. One must be able to compare the additional costs created by the alternative design, in relation to the existing design, with the costs of the injuries that the alternative design could prevent. In the Pinto case, Ford obviously undertook this analysis, examining the additional $11 cost per unit of changing the fuel system design.

3. Economic Feasibility of Valuing Non-Economic Items

The decision to use a risk/benefit analysis does not necessarily result in the strict utilitarianism as suggested by some critics. Most all detractors of cost/benefit analysis center their argument around the idea that placing a value on "non-economic" items, such as a human life, does not lead to economic efficiency. Proponents of the system claim their risk/benefit analysis is nothing more than what it claims to be--an effort to find some common measure for things that are not easily comparable, yet must be compared. While this may seem crass--comparing lives to dollars--some comparison must be made and all the factors in the equation must be brought down to a common denominator for the comparison to take place. Other instances arise where lives are traded against lives, just not brought down to the dollar amount that took place in the Ford Pinto case. In the choice between hospital beds and preventive treatment, lives are traded against lives. It is when the analysis is taken down to an individual level that it becomes problematic.

Economists dispel the related argument just as easily. The idea that if one can quantify "non-economic" items, there are certain "specially valued" things that cannot be priced. It is true that different individuals value certain things differently, but simply because an individual deems something has "special value" does not mean that they are unaffected by economic factors. One may specially value a personal relationship, but how often he calls this person is influenced by long-distance rates. One may specially value music or watching sporting events, but still can be affected by the price of records and tickets to the Kennedy Center or the price for watching events on cable or a ticket to the ball game.

4. Efficiency Does Not Equal Immoral

Critics look at risk/benefit analysis in cases such as the Ford Pinto case as a depravity of morality. The idea is that everyone has the "right" to a safe and healthy workplace, or the "right" to expect product they purchase to be safe. Those who subscribe to this philosophy feel there are some "moral" decisions that must be made no matter what the fiscal impacts may be or what the risk,/benefit relationship dictates. Proponents of the risk/benefit analysis counter this "ethical" argument with the idea that these are not either/or decisions being made, but rather gradations of risk. That is, Ford is not sacrificing all safety features of the Pinto, it is a question of to what degree Ford feels safety features are necessary. It could be argued that the safety question was answered for them prior to the risk/benefit analysis when Ford's earlier advertising campaign based on safety failed. Decisions involving gradation of risks are made every day, just not under such strict scrutiny. Obviously, highways would be safer if the speed were restricted to 25 miles per hour on all roads. However, this must be balanced with the "price" of slower traffic. in choosing 55 or 65 as the speed limit, we are sacrificing lives to make travel quicker and less costly. Therefore, the Ford Motor Company is not morally void for choosing between levels of safety. Auto manufacturers do this every day.

5. No Standard for Using an "Ethical Balancing"

All of the arguments against the use of risk/benefit analysis seem to center around the "ethical argument." Instead of a monetary system, sire should adopt an ethical system that balances conflicts between certain unspecified duties and rights according to "deliberate reflection. While placing dollar amounts on these items is admittedly arbitrary, the "ethical" method would open a much larger debate. Who would be in charge of this ethical reflecting and on whose behalf would these decisions be made? There would be no clear limits for the actions of regulatory agencies. What public values would rise above these vague guidelines? Finding or arriving at a consensus for this ethical standard is virtually impossible.

6. Conclusion

In conclusion, all of the arguments against Judge Posner's negligence-efficiency argument center around valuing human life. Is it possible to set a price for all things, especially a human life? Is it ethically correct to attempt to do such a thing? Should a company be allowed to use this standard to determine whether to "upgrade" an automobile. The answer to all of these questions is yes. The use of the risk/benefit analysis maximizes overall economic value and general welfare. In fact, these choices are subconsciously made by individuals, companies and governmental agencies on an everyday basis. Judge Posner argues this standard was used long before Judge Learned Hand first expressed it in algebraic terms in Carroll

Towing. While criticizing the numbers or values used by the Ford Motor Company in the risk/benefit analysis may be valid, the use of the risk/benefit analysis itself cannot be questioned.

V1I. Conclusion

Through years of case law, the negligence and products liability standard has evolved. Many will argue that courts have "subconsciously" used cost/benefit analysis for many decades, especially with the old "reasonable man" standard. However, Judge Hand finally established this standard in Carroll Towing, explicit acknowledging the "BPL" formula. Judge Posner gave the standard a ringing endorsement in an article in 1972, defending it on economic efficiency grounds. Since that time it has been the source of hot debate.

While not absolutely perfect, the risk/benefit standard for negligence advances overall economic value and welfare, is economically efficient, and therefore is the correct standard to apply (or at least the best option). Criticism of the standard almost always occurs when looking at the standard on an individual case-by-case basis. Critics and laypeople have a difficulty valuing non-economic entities as is required by the formula. Approaching it in this manner, it seems insulting to place a monetary value on a life. This is where the efficiency standard ran into trouble in the Ford Pinto case. One must realize these "valuations" and determinations are part of everyday public policy. In determining safety and environmental standards, a choice must be made as to what level these areas should be regulated.

The Ford Motor Company was not wrong in applying this risk/benefit standard. While the numbers the company used in its analysis may be questioned, the decision to employ the framework which resulted in the decision not to redesign the fuel system shouldn't be. Ford ran into the; trouble of taking this framework and having to justify it on a individual case basis, as a result of the lawsuits. In addition, the Ford Motor Company was an attractive defendant to find liable. The jury's disgust with the deep-pocketed defendant and the troubling value of a life concept was evidenced by the ridiculous punitive damage award initially granted to the plaintiff Obviously, one cannot assume a jury will understand the economic efficiency of the risk/benefit analysis. Even if they do, who knows what they will decide anyway? This fact raises the question--If the Hand risk/benefit formula is truly used to decide negligence cases as Judge Posner claims, why isn't the jury instructed about it.

In conclusion, this framework is economically efficient and the proper one to apply. However, companies beware. The result of the Ford Pinto case indicate there is a belief held by most of the public that it is wrong for a corporation to make decisions which may sacrifice the lives of its customers in order to reduce the company's cost or increase its profits. With this widespread attitude among those who make up juries, trial lawyers would not be wise; to defend cases on the economic analysis of why it was not efficient to redesign a faulty model. Instead, trial lawyers argue that the alternative design compromises the product's function or creates different risks in the product, but not that the costs of the alternative design outweigh the injury or death toll that may be avoided. These options did not seem plausible in Ford's case, which spelled trouble. Therefore, while it may be valid economic efficiency reasoning, the Ford Motor Company and others are forced to think twice before utilizing a risk/benefit analysis in their decision making process.

References

1. Grimshaw v. Ford Motor Co., 1 19 Cal.App.3d 757, 174 Cal. Rptr. 348 (1981).
2. In the resulting suits against Ford, the jury--after deliberating for eight hours-awarded the Gray family wrongful death damages of $560,000; Grimshaw was awarded over $2.5 million in compensatory damages and $125 million in punitive damages as well. The trial judge reduced the punitive damage

award to $3.5 million as a condition for denying a new trial. Two years after the court of appeals affirmed these results in all respects, the state supreme court then denied a hearing. See Gary T. Schwartz, The Myth of the Ford Pinto Case, 43 Rutgers L. Rev. 1013, 1015 (1991).
3. State v. Ford Motor Co., Cause No. 11-431 (1980).
4. See Malcom E. Wheeler, Product Liability, Civil or Criminal -- The Pinto Litigation, ABA, Tort and Insurance Law Journal, 14, 1981.
5. See Douglas Birsch and John H. Fielder, THE FORD PINTO CASE: A STUDY IN APPLIED ETHIC'S, BUSINESS, AND TECHNOLOGY, 1994.
6. See Wheeler, supra note 4, at 15.
7. Id.
8. The prosecutor of Elkhart County, Indiana, chose to seek an indictment against Ford Motor Company for reckless homicide and criminal recklessness, claiming that the cause of the deaths was the design of the Pinto and Ford's failure to "remove the car from the highways" before August 10, 1978. See Wheeler, supra note 4, at 15.
9. The prosecutor obtained information against the van driver for possession of amphetamines. Rather than promptly proceeding to judgment and sentencing on that charge, he kept those charges hanging over the van driver's head until after March 1980, when the driver had testified against Ford and the trial of Ford had ended. Moreover, the pills reported as amphetamines in the official police report were later analyzed and determined to be caffeine pills:, but that information was concealed from Ford's lawyers until after the driver took the stand at trial, and the charge of possessing amphetamines was kept pending throughout the trial. See Wheeler, supra note 4, at 15.
10. Mark Dowie, Pinto Madness, Mother Jones 18 (Sept./Oct. 1977).
11. Goodyear had developed a bladder and demonstrated it to the automotive industry. On December 2, 1970, Ford Motor Company ran a rear-end crash test on a car with the rubber bladder in the gas tank. The tank ruptured, but no fuel leaked. On January 15, 1971, Ford again tested the bladder and it worked. Mark Dowie, Pinto Madness, Mother Jones, Sept./Oct. 1977, at 20.
12. The total purchase and installation cost of the bladder would have been $5.08 per car. Mark Dowie, Pinto Madness, Mother Jones, Sept./Oct. 1977, at 20.
13. Ford contended that its reason for making the cost/benefit analysis was that the National Highway Traffic Safety Administration required them to do so. Moreover, Ford said that the NHTSA supplied them with the $200,000 as the figure for the value of a lost life. Richard A. Posner, TORTS: CASES AND ECONOMIC ANALYSIS 725 (1983).
14. Barbara Ann White, Risk-Utility Analysis and the Learned Hand Formula: A Hand That Helps or a Hand That Hides?, 32 Ariz. L. Rev. 77, 81 (1990).
15. "A perfect locomotive engine, properly equipped and properly run, will not ordinarily throw out sufficient sparks to destroy adjoining property." Judson v. Giant Powder Co., 107 Cal. 549, 500, 40 P. 1021, 1023 (1985).
16. See White, supra note 12, at 82.
17. Id. at 88.
18. Brown v. Kendall., 60 Mass. (6 Cush.) 292 (1850).
19. Id. at 294-95 (emphasis added).
20. Id. at 296.
21. Crain v. Petrie, 6 Hill 522 (ICY. Sup. Ct. 1844).
22. Id. at 524.
23. See White, supra note 12, at 90.
24. The inquiry into defendant's knowledge and actions was framed in a way to determine if the harm was really the result of a convolution of events rather than defendant's conscious deeds. 1fd. at 90.

25. 60 Mass. (6 Cush.) 292, 297 (1850).
26. In Vincent v. Stinehour, 7 Vt. 62 (1835), the court stated, "If the horse, upon a sudden surprise, run away with his rider, and runs against a man and hurts him, this is not battery. Where a person , in doing an act which it is his duty to perform, hurts another, hs is not guilty of battery .... A soldier, in exercise, hurts his companion--no recovery can be had against him.... If the act which occasioned the injury to the plaintiff was wholly unavoidable, and no degree of blame can be imputed to the defendant, the conduct of the defendant was no unlawful."'

Similarly, in Lehigh Bridge v. Lehigh Coal & Navig. Co., 4 Rawle 8 (Pa. 1833), the court stated, "The defendant had the ... right to erect the damn at the particular place ... and if chargeable with no want of attention to its probable effect, is not answerable for consequences which it was impossible to foresee and prevent. Where a loss happens exclusively from an act of Providence, it will not be pretended that it out to be borne by him whose superstructure was made the immediate instrument of it.
27. Huntress v. Boston & Main R. R., 66 N. H. 185, 34 A. 156 (1870).
28. Id. at 191-192, 34 A. at 157.
29. In Butcher v. Vaca Valley & Clear Lake R.R, 67 Cal. 518, 8 P. 174 (1885), the California Supreme Court decided that a presumption of negligence was raised by evidence that, theoretically, a railroad engine could be made that would not provide fire causing sparks. Therefore, the court found that the railroad engine's production of sparks was, in fact, prima facie proof of defendant's negligence. In Giraudi v. Electric Imp. Co., 107 Cal. 120, 40 P. 108 (1895), a restaurant employee went on the roof to repair a sign during a heavy thunderstorm. He inadvertently came in contact with a power line that he knew was there. The court upheld a jury verdict against the power company, stating that electricity was dangerous and that the defendant had to take the utmost standard of care.
30. Adams v. Bullock, 227 N.Y. 208, 125 N.E. 93 (1919).
31. Id. at 210, 125 N.E. at 93.
32. Id.
33. Id.
34. Id. at 211, 125 N.E. at 94.
35. See White, supra note 12, at 83.
36. Id. at 85.
37. United States v. Carroll Towing, 159 F.2d 169 (2d Cir. 1947).
38. David W. Barnes and Lynn A. Stout, CASES AND MATERIALS ON LAW AND ECONOMICS 93 (1992).
39. Id. at 94.
40. Id. at 95.
41. Carroll Towing Co., 159 F.2d 169 (2d Cir. 1947).
42. Greenman v. Yuba Power Products, Inc., 59 Cal.2d 57, 377 P.2d 897, 27 Cal. Rptr. 697 (1963).
43. Id.
44. See White, supra note 12, at 106.
45. In MacPherson v. Buick Motor Company, 217 N.Y. 382, 111 N.E. 1050 (1916), Judge Cardozo removed the requirement of privity of contract that prevented the ultimate purchaser from suing the manufacturer in tort for harms arising out of the use of his product. Prior to this decision, the manufacturer was liable only to the immediate purchaser who was usually a middle man and not the ultimate user. The demise of the requirement of privity, however, *did not* alleviate the plaintiff's evidentiary problems of proving defendant's negligent behavior. Until the landmark decision of Greenman v. Yuba Power Products, Inc., 59 Cal..2d 57, 377 P.2d 897, 27 Cal. Rptr. 697 (1963), substantial legal loopholes enabled manufacturers to avoid liability for harms the courts clearly wanted to impose.

46. Greenman, 59 Cal.2d 57, 377 P.2d 897, 27 Cal. Rptr. 697 (1963).
47. The court stated, "A manufacturer is strictly in tort when an article he places on the market .... proves to have a. defect that causes injury to a human being." Id.
48. RESTATEMENT (SECOND) OF TORTS § 402A, comment g (1965).
49. See White, supra note 12, at 108.
50. Caterpillar Tractor Co. v. Beck, 593 P.2d 886 (Alaska 1979).
51. Id. at 886. (emphasis added).
52. Turner v. General Motors Corp., 584 SW.2d 844 (Tex. 1979).
53. Id. at 847 n.1. (emphasis added).
54. See White, supra note 12, at I 11.
55. Dennis A. Gioia, Pinto Fires and Personal Ethics: A Script Analysis of Missed Opportunities, JOURNAL OF BUSINESS ETHICS 11, 381 (1992).
56. One document that was not sent to Washington by Ford was a "Confidential" cost analysis *Mother Jones* was able to obtain, showing that crash fires could be largely prevented for considerably less than $11 a car ... The total purchase and installation cost of the bladder would have been $5.08. *Dowie*,Pinto Madness, MOTHER JONES 18 (Sept./Oct. 1977).
57. See Gioia, supra note 53, at 382.
58. See, e. g., The T.J. Hooper, 60 F.2d 737 (2d Cir. 1932): The court acknowledged that at the time of an accident, custom in the tug industry was not to carry radios to check weather reports.. Even though this was the case, it found a tug line liable: "But here there was no custom at all as to receiving sets; some had them, some did not; the most that can be urged is that they had not yet become general ... We hold the tugs (liable) because had they been properly equipped, they would have gotten the weather reports."
59. See Dowie, supra note 54.
60. Id.
61. Posner, A Theory of Negligence, 1 J. LEGAL STUD. 29, 29, 32-34 (1972).
62. See Birsch, supra note 3, at 159.
63. Id. at 160.
64. Id. at 161.
65. Id. at 129.
66. See Birsch, supra note 3, at 129.
67. Id.
68. Economists have tried to develop methods for imputing a person's "willingness to pay" for such things, their approach generally involving a search for bundled goods that care traded on markets and that vary as to whether they include a feature that is, by itself; not marketed. Thus, fresh air is not marketed, but houses in different parts of Los Angeles that are similar except for the degree of smog are. Id.
69. Id. at 133.
70. Frank J. Vandall, Judge Posner's Negligence Efficiency Theory: A Critique, 35 EMORY L.J. 383, 391 (1986).
71. Coleman, Efficiency, Utility, and Wealth Maximization, 8 HOFSTRA L. Rev. 509, 526 (1980).
72. See 2 F. HARPER & F. JAMES, THE LAW OF TORTS 743 (1956).
73. See Vandall, supra. note 68, at 199.
74. Rizzo, Law Amid flux: The Economics of Negligence and Strict Liability in Tort, 9 J. LEGAL STUD. 291, 299 (1980).
75. See Vandall, supra note 68, at 389.
76. Id. at 402.

77. A. POLINSKY, AN INTRODUCTION TO LAW AND ECONOMICS 12326, at 46-47 (1983)
78. See Vandall, supra note 68, at 405.
79. See generally William M. Landes & Richard A. Posner, The Economic Structure of Tort Law, 23 (1987).
80. Michael D. Green, Negligence = Economic Efficiency: Doubts, 75 Tex. L. Rev. 1605, 1607 (1997).
81. Id. at 1608.
82. Id.
83. Id.
84. Id. at 1609.
85. Id.
86. See Birsch, supra note 3, at 137.
87. Id. at 139.88. Id. at 138.
89. See Green, supra note 78, at 1631.
90. Id. at 1642.
91. Id.