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Engineering Ethics and Risk

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Description

This annotated bibliography includes articles on risk identification, risk assessment, risk management, and risk communication.

Body

Risk Identification

Barati, Samaneh and Shahriyar Mohammadi. 2008. Enhancing Risk Management with an Efficient Risk Identification Approach in *4th IEEE International Conference on Management of Innovation and Technology,* Bangkok, Thailand. 21-24 September 2008, pp. 1181-1186.
Risk identification is one of the most important steps of risk management, and consists of discovering, defining, describing, documenting and communicating risks before they become a problem and adversely affect a project. This paper analyzes the risk identification process from all points and describes a new model for risk management with a focus on risk identification.

Murphy, Colleen, Paolo Gardoni and Charles E. Harris. 2011. Classification and Moral Evaluation of Uncertainties in Engineering Modeling. *Science and Engineering Ethics.* 17(3): 533-570.
Engineers must deal with risks and uncertainties as a part of their professional work

and, in particular, uncertainties are inherent to engineering models. Models play a central role in engineering but often represent an abstract and idealized version of the mathematical properties of a target. Using models, engineers can investigate and acquire understanding of how an object or phenomenon will perform under specified conditions. This paper defines the different stages of the modeling process in engineering, classifies the various sources of uncertainty that arise in each stage, and discusses the categories into which these uncertainties fall. The paper then considers the way uncertainty and modeling are approached in science and the criteria for evaluating scientific hypotheses, in order to highlight the very different criteria appropriate for the development of models and the treatment of the inherent uncertainties in engineering. Finally, the paper puts forward nine guidelines for the treatment of uncertainty in engineering modeling.

Rizak, Samantha and Steve E. Hrudey. 2005. Interdisciplinary Comparison of Risk Beliefs. *Journal of Environmental Engineering and Science.* 4(3): 173-185.

There is increasing awareness that discrepancies in risk judgments between experts, in addition to those with the public, are a major difficulty in achieving effective risk communication. This article reports on a survey of members of different environmental disciplines to determine the extent to which these individuals share similar beliefs and conceptual frameworks concerning basic assumptions in environmental health risk assessment. The results showed that divergent interpretations did exist among respondents on several issues, and even between members of the same discipline. In light of these difficulties in evaluating and communicating risk, experts should evaluate their own knowledge and understanding of these concepts and should be fully aware of the strengths and limitations of the methods used for risk assessment.

Schleyer, Graham, Rui Fang Duan, Julian Williamson, Nicola Stacey. 2007. Assessing the Awareness of Risk Concepts by new Engineering Students. *International Journal of Mechanical Engineering Education.* 35(3): 184-197.

In order to assess the level of student comprehension related to risk concepts in engineering, this UK study, which sought to incorporate risk education into the curriculum of an undergraduate engineering course in a UK university for the 2005/06 academic year, developed a questionnaire based on learning objectives developed by the researchers that was designed to assess students' awareness of risk issues. This paper describes the development of the questionnaire, the

interpretation of the results, and how the questionnaire will be used to help achieve the desired learning outcomes.

Shrader-Frechette, K.S. 1986. The Conceptual Risks of Risk Assessment. *IEEE Technology and Society Magazine.* 5(2): 4-11.
Many, if not most, risk assessors allege that their methods of risk identification and risk estimation are wholly objective. Contrary to this view, it can be shown that a variety of value judgments are inherent in classical risk assessment methods. In addition to these methodological threats to objectivity, there are at least three ethical problems which require risk assessors or policymakers to make normative decisions. After outlining these ethical and methodological difficulties, this essay closes with two suggestions for improving risk assessment and for rendering its evaluative components explicit.

Risk Assessment

Allinson, R.E. 1999. The epistemological and ethical basis of risk assessment in advanced technological systems: the lesson of the Challenger. *International Journal of Technology Management.* 17(1-2): 54-74.
This paper is devoted to showing that a safety priority should be accorded the highest priority in decision making and that such prioritization is an ethical responsibility. This paper exposes the illogic behind the misleading phrase 'risky technology' and the fallacies which underlie the seemingly morally neutral phrase 'risk assessment'.. To be ethically sound, risk assessment must take into account not only probabilities of occurrence but consequences of occurrence, such as life or death risks to risk takers and all those on whom the risk taken will ultimately make an impact. It is argued that risk takers possess a right to know of the specific risks to which they are exposing themselves and that risk makers possess the corresponding duty to inform risk takers. The Challenger case is utilized as a lesson in unsound and unethical risk assessment.

Gotterbarn, Don, Tony Clear and Choon-Tuck-Kwan. 2008. “Chapter 18: A Practical Mechanism for Ethical Risk Assessment – A SoDIS Inspection” in Himma, Kenneth Einar, Herman T. Tavani (eds.). *A Handbook of Information and Computer Ethics*. Hoboken, N.J.: John Wiley & Sons Inc.

pp.429-472.
This book chapter investigates the role risk assessment plays in the development of high-quality computer software and introduces the reader to some different generic risk analysis models. The author then explains how the Software Development Impact Statements (SODIS) process can help improve software quality by ensuring that the needs and potential risks by all project stakeholders are considered. The chapter goes on to look at the development of SoDIS and its potential benefits as a way for identifying and solving ethical issues that may the rise in the course of a project.

Grunwald, Armin. 1999. Technology Assessment or Ethics of Technology: Reflections on Technology Development between Social Sciences and Philosophy. *Ethical Perspectives.* 6(2): 170-182.
Handling the impacts and consequences of technology has been a problem of political, social, and scientific relevance since the 1960's. This article looks at two different types of ethical risk assessment, the ethics of technology and technology assessment. The first emphasizes the normative implications of decisions on technology and the importance of moral conflicts, which the second relies on descriptive sociological or economic research. The paper looks at the conflicting arguments postulated by the proponents of these two approaches and the author argues why the ethical considerations concerning the problems of shaping technology should not be confined to engineering ethics.

Lough, Kate Grantham, Robert Stone and Irem Y. Tumer. 2009. The Risk in Early Design Method. *Journal of Engineering Design.* 20(2): 155-173.
Risk assessments are necessary to anticipate and prevent accidents from occurring or repeating. Since product design safety and reliability are affected the most by decisions made during the early design phases, a risk assessment that can be performed with less mature data during these design phases is needed. This study focuses on the relationship between function and risk in early design by presenting a mathematical mapping from product function to risk assessments that can be used in the conceptual design phase. An investigation of a spacecraft orientation subsystem is used to demonstrate these mappings.

National Research Council. Committee on Improving Risk Analysis Approaches Used by the U.S. EPA. 2009. Science and Decisions: Advancing Risk Assessment. Washington D.C.: National Academies Press.
Risk assessment has become a dominant public policy tool for making choices based

on limited resources, to protect public health and the environment. This report looks at some of the many problems individuals involved in risk assessment can face, especially with regards the U.S. Environmental Protection Agency, and makes practical scientific and technical recommendations to address these challenges. Though this publication is aimed at individuals working in the regulatory and public heath fields, the concepts discussed are likely to be of use to engineers whose work can raise public health and environmental concerns.

Nelson, Kristen C., David A. Andrew and Michael J. Banker. 2009. Problem Formulation and Option Assessment (PFOA) Linking Governance and Environmental Risk Assessment for Technologies: A Methodology for Problem Analysis in Nanotechnologies and Genetically Engineered Organisms. *Journal of Law, Medicine, and Ethics.* 37(4): 732-748.
Societal evaluation of new technologies, specifically nanotechnology and genetically engineered organisms, challenges current practices of governance and science. Employing environmental risk assessment (ERA) for governance and oversight assumes we have a reasonable ability to understand consequences and predict adverse effects. However, traditional ERA has come under considerable criticism for its many shortcomings and current governance institutions have demonstrated limitations in transparency, public input, and capacity. The authors of this article suggest that Problem Formulation and Options Assessment (PFOA), may be a better alternative approach. This is a methodology founded on three key concepts in risk assessment (science-based consideration, deliberation, and multi-criteria analysis) and three in governance (participation, transparency, and accountability).

Macpherson, James A.E. 2008. Safety, Risk Acceptability, and Morality. *Science and Engineering Ethics.* 14(3): 377-390.
This article gives a conceptual analysis of safety and argues that previous analyses of safety in terms of risk acceptability fail because the notion of risk acceptability is more subjective than safety, as risk acceptability takes into account potential benefits in a way that safety does not. The paper further explores questions about the nature of safety in relation to the potential of a thing to cause harm, as well as in relation to the potential of someone being harmed.

Petrenko, Anton and Dan McArthur. 2010. Between Same Sex Marriages and the Large Hadron Collider: Making Sense of the Precautionary Principle. *Science and Engineering Ethics.* 16(3): 591-610.
The Precautionary Principle is a guide to coping with scientific uncertainties in the

assessment and management of risks. In recent years, it has moved to the forefront of debates in policy and applied ethics, and is being used in areas as diverse as as environmental and health regulation and product development. While many claim that the principle is incoherent, this paper seeks to answer these criticisms by formulating guidelines for its application that ensure its coherence as a useful normative guide in applied and policy ethics debates.

Pieters, W. and A. van Cleeff. 2009. The Precautionary Principle in a World of Digital Dependencies. *Computer.* 42(6): 50-56.
This article suggests that in the risk assessment of software, we can no longer rely on the ethics of consequences but might instead rely on the precautionary principle, which lets software engineers focus on creating a more extensive moral framework.

Ross, Allison and Nafsika Athanassoulis. 2010. The Social Nature of Engineering and its Implications for Risk Taking. *Science and Engineering Ethics*. 16(1): 147-168.
This article looks at the risk assessment often done by engineers when making decisions about a project. Whether it be decisions about the design of products, manufacturing processes, public works, or developing technological solutions to environmental, social and global problems, risk taking seems inherent to the profession. The authors discuss how our understanding of engineering as a distinctive profession might affect how we should make decisions under risk.

Uddin, Nasim and Alfredo H.S. Ang. 2011. *Quantitative Risk Assessment for Natural Hazards.*
This short booklet explains the practical aspects of using quantitative risk assessment to develop optimal engineering designs that mitigate the effects of natural hazards, especially on civil infrastructure.

Wetmore, Jameson M. 2008. Engineering with Uncertainty: Monitoring Air Bag Performance. *Science and Engineering Ethics.* 14(2): 201-218.
Modern engineering is filled with uncertainties, and in some cases these uncertainties can prove to have adverse consequences can include possible health and safety implications. However, due to the inherent limits of testing and the complexities of the world outside the lab, engineers will never be able to fully predict how their creations will behave. However, one way of dealing with this uncertainty in some cases is to actively monitor technologies once they have left the development and product stage. This article discusses an instance in the history of

automobile air bags as an example of engineers who had the foresight to carefully tract the technology on the road to discover problems as early as possible.

Risk Management

Chowdhury, Abdullah Al and Shamsul Arefeen. 2011. Software Risk Management: Importance and Practices. *International Journal of Computer and Information Technology.* 2(1): 49-54.
http://www.ijcit.org/ijcit_papers/vol2no1/IJCIT-110740.pdf
Software risk management is a software engineering practice with processes, methods, and tools for managing risks in a project. It provides a disciplined environment for proactive decision-making to assess continuously what can go wrong, determine what risks are important to deal with, and implement actions to deal with these risks. This paper looks at the increasing role of risk assessment in present software projects and looks in detail and the steps of this process, including risk identification, assessment, and mitigation.

Ersdal, Gerhard and Terje Aven. 2008. Risk Informed Decision-Making and its Ethical Basis. *Reliability Engineering & Safety Systems.* 93(2): 197-205.
When making decisions in the face of uncertainty, there are two main questions that need to be asked: 1) What are the future consequences and associated uncertainties of an action and, 2) what is the right decision or action to make? This paper evaluates the different risk management approaches for establishing good decisions using different ethical theories as a basis. These theories include the utilitarian ethics of Bentley and Mills, and the deontological ethics of Kant, Rawls and Habermas. The risk management approaches discussed in this article include cost-benefit analysis, minimum safety criterion, the ALARP principle and the precautionary principle.

Hasson, Sven Owe. 2009. From the Casino to the Jungle: Dealing with Uncertainity in Technological Risk Management. *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science.* 168(3): 423-432.
Clear-cut cases of decision-making under risk (known probabilities) are unusual in real life. The gamblers decisions at the roulette table are as close s we can get to this type of decision-making. In contrast, decision-making under uncertainty

(unknown probabilities) can be exemplified by a decision whether to enter a jungle that might contain unknown dangers. Nevertheless, it is common in decision-supporting disciplines to proceed as if reasonably reliable probability estimates were available for all possible outcomes, i.e., as if the prevailing epistemic conditions were analogous to those of gambling at the roulette table. This mistake can be called the 'tuxedo fallacy'. It is argued that traditional engineering practices such as safety factors and multiple safety barriers avoid this fallacy and that they therefore manage uncertainty better than probabilistic risk analysis (PRA). PRA is a useful tool, but it must be supplemented with other methods in order not to limit the analysis to dangers that can be assigned meaningful probability estimates.

Lundgreen, P. 197. Handling Risk: Expertise and Regulatory Politics in Germany, 1870-1913. *IEEE Technology and Society Magazine*. 16(1): 16-22.
This study of Germany reveals that the successful handling of risk through regulatory politics based on scientific expertise results from three essentials: (1) government bureaus for research and testing as applied to specific areas of risk; (2) the participation of interested parties in bargaining about standards and values; and (3) a mentality of the public at large to accept limited risks if they are part of the so-called “acknowledged scientific and technical practice”. Such a pattern of regulation came to birth during the last few decades of the 19th Century and has been in force ever since in industrialized societies. It has found its best manifestation in the model of “standardization by limiting values”, which symbolically combines the instrumentalist and the legitimizing functions of science in the processes of regulation.

Mayo, Deborah and Rachelle D. Hollander. 1991. *Acceptable Evidence: Science and Values in Risk Management.* New York: Oxford University Press.
This volume analyzes assumptions underlying environmental and medical controversies, and the scientific and statistical models used in risk management. It denies two assumptions about risk evidence that have been barriers to progress; that it is largely a matter of objective scientific data, and that it is a matter of societal values and not amenable to reasoned critique. The goal is an approach to risk assessment that is not victimized by the view that scientific rationality requires value-free methods of the view that no risk assessment is better than another. Contributors include philosophers, policy analysts, and natural and social scientists.

National Academy of Engineering. 2004. *Accident Precursor Analysis and Management: Reducing Technological Risk Through Diligence.* Washington, D.C.: National Academies Press. In the aftermath of catastrophes, it is common to find prior indicators, missed signals, and dismissed alerts that might have signaled impending danger and even averted the catastrophe. This report documents industrial and academic approaches for detecting, analyzing, and benefiting from accident precursors and examines public and private sector roles in the collection and use of precursor information. The report also includes 11 different background papers that discuss the opportunities of precursor analysis and management, risk assessment, risk management, and linking risk assessment and risk management.

Peterson, A.K., J.H. Reynolds, and L.W. T. Ng. 2008. The Attitude of Civil Engineering Students Towards Health and Safety Risk Management: A Case Study. *European Journal of Engineering Education.* 33(5-6): 499-510.
The highest rate of accidents and injuries in British industries has been reported by the construction industry during the past decade. Since then stakeholders have recognized that a possible solution would be to inculcate a good attitude towards health and safety risk management in undergraduate civil engineering students and construction professionals. Consequently, the four accreditation bodies that accredit construction degrees have improved coverage of health and safety risk management. This paper demonstrates innovative assessment methods that have been used to inculcate a safety conscious attitude into undergraduate civil engineering students, and to improve their knowledge of health and safety risk management.

Pinkus, Rosa Lynn B.1997. *Engineering Ethics: Balancing Cost, Schedule, and Risk – Lessons Learned from the Space Shuttle.* Cambridge, U.K.: Cambridge University Press.
Using the space shuttle program as its framework, this book examines the role of ethical decision making in the practice of engineering. In particular, the authors consider the design and development of the main engines of the space shuttle as a paradigm for how individual engineers perceive, articulate, and resolve issues of risk in a large, complex organization.

Rubio, Carmen M. Antonio Menéndez, Carlos I. Rubio and German Martínez. 2005. Obligations and Responsibilities of Civil Engineers for the Prevention of Labor Risks: References to European Regulations. *Journal of*

***Professional Issues in Engineering Education and Practice*. 131(1): 70-75.**
Focuses on the obligations and responsibilities of civil engineers in the prevention of labor risks in the construction industry. Economic and social costs associated with labor accidents; Duties of the coordinator for safety and health matters at the project implementation stage; Obligations of contractors and subcontractors.

Vallero, Daniel A. and Aarne P. Vesilind. 2007. *Socially Responsible Engineering: Justice in Risk Management.* Hoboken, N.J.: John Wiley. Xii, 365 p.
This book focuses on environmental aspects of engineering ethics, gives a historic and philosophical background for the concept of environmental justice, and discusses the technical tools necessary to help engineers evaluate projects for an ethical perspective and to properly access the risk it presents to communities that may be impacted.

Welsh, Rick and David E. Ervin. 2006. Precaution as an Approach to Technology Development: The Case of Transgenic Crops. *Science, Technology, and Human Values.* 31(2): 153-172.
The authors argue that novel technology development and associated scientific uncertainty has led to two competing approaches to risk management: precaution and ex post trial and error. The paper uses the controversies over transgenic crops to analyze the debate on these two competing approaches, and finally suggest a hybrid approach that incorporates the precautionary selection process, but also relies on ex post trial and error after commercialization of a product.

Wetmore, Jameson M. 2004. Redefining Risks and Redistributing Responsibilities: Building Networks to Increase Automobile Safety. *Science, Technology, and Human Values*. 29(3) : 377-405.
This article draws on the history of automobile safety in the United States to illustrate how technical design has been used to promote or maintain duties, values, and ethics. It examines two specific episodes: the debates over the “crash avoidance” and “crash-worthiness” approaches in the 1960s and the responses to the accusation that air bags were killing dozens of people in the mid-1990s. In each of these debates, certain auto safety advocates promoted the development of technologies designed to circumvent, replace, or compensate for “irresponsible” human actions because they believed that devices and techniques would be considerably more obedient and reliable than the American public. Other organizations, however, contested such reallocations because they also involved a

shift in responsibilities throughout the rest of the socio-technical network of auto safety. This article argues that those who controlled the precise definition of risk in auto safety had the upper hand in constructing both the solution to the problem and the distribution of responsibilities the solution entailed.

Yohe, Gary. 2010. Risk Assessment and Risk Management for Infrastructure Planning and Investment. *The Bridge.* 40(3): 14-21.
This article discusses the role that risk assessment and management plays in engineers' and policy makers' attempts to respond to climate change, and after discussing some of the fundamentals of these concepts, goes on to look at how New York City is using risk assessment and management to include climate change in its planning processes to protect public and private infrastructure .

Risk Communication

Bier, V.M. 2001. On the State of the Art: Risk Communication to the Public. *Reliability Engineering and System Safety.* 71(2): 139-150.
This paper provides an overview of the state of the art in the area of risk communication. It first looks at empirical results regarding the format of risk communication messages to the public, the use of risk comparisons, audience differences, and the use of mental models as an aid in crafting effective risk communication messages. The paper also looks at issues of credibility and trust in risk communication, and the use of stakeholder participation processes.

Herkert, Joseph R. 1994. Ethical Risk Assessment: Valuing Public Perceptions. *IEEE Technology and Society*. 14(10): 4-10.
The author examines the connections between engineering ethics, risk communication, and the engineering culture, and looks at how risk communication could be made into a two-way conversation between experts and the public.

Kaperson, Roger E. 2005. *Social Contours of Risk: Volume I: Publics, Risk Communication and the Social.* Sterling, VA: Earthscan.
This volume includes a number of essays looking at how risks are communicated among different publics and stakeholders, including local communities, corporations, and the larger society. It looks at the problems that are caused by a lack of transparency and trust, and explores how even minor effects can be amplified and distorted by media and social responses, preventing effective management of these

issues.

Palenchar, M. J., Heath, R. L., & Dunn, E. 2005. Terrorism and industrial chemical production: A new era of risk communication. *Communication Research Reports*, 22(1):59–67.
The increased threat of and heightened concerns for terrorist attaches has reinvigorated the debate about industrial production security efforts, especially in the chemical manufacturing and refining industry. The authors of this paper performed a telephone survey of 400 researchers that examined public perceptions of industry preparedness in event of terrorism. The survey found that near-neighbor residents of these kind of industrial facilities expressed more trust for local industry and government officials when they were made aware of the industry's efforts to safety and terrorism, and were more supportive of the local chemical industry.

Pidgeon, Nick and Tee Rogers-Hayden. 2007. Opening Up Nanotechnology Dialogue with the Publics: Risk Communication or "Upstream Engagement"? *Health, Risk, and Society.* 9(2): 191-210.
The authors discuss the origins of upstream engagement (public participation before significant research has been done and before firm public attitudes about an issue have been established) and how this kind of public engagement is being promoted in the United Kingdom. Using the example of the NanoJury project, the authors argue that for upstream engagement to be effective, new approaches must be developed to open up the debate about the value of nanotechnology research and development.

Priest, Susanna Hornig. 2009. Risk Communication for Nanobiotechnology: To Whom, About What, and Why? *Journal of Law, Medicine, and Ethics.* 37(4): 759-769.
Regulatory oversight and public communication are intimately intertwined. Oversight failures quickly galvanize media and public attention. In addition, regulations sometimes require that risks and uncertainties be included in communication efforts aimed at non-experts outside of the regulatory and policy communities — whether in obtaining informed consent for novel medical treatments; by including risk information on drug labels, in drug advertisements, or on chemicals used in the workplace; in providing nutritional information on food packages; or by opening environmental impact assessments to public comment. This article discusses six models of upstream public risk communication and uses those models to analyze the communication challenges facing nanotechnology and

nanobiotechnology. The author also reviews the communication dynamics associated with the historical cases of technology regulation including genetically engineered organisms [GEOs] in the food supply, pharmaceuticals and medical devices, chemicals in the workplace, and gene transfer research or “gene therapy” to help shed light on the communications challenges facing nanobiotechnology.

Thompson, Paul B. 1999. The Ethics of Truth-Telling and the Problem of Risk. *Science and Engineering Ethics*. 5(4): 489-510.
The author looks at the problem of explaining why truth-telling is problematic in reconciling expert and lay attitudes toward risk. Evaluating risk always incorporates an estimate of the reliability of information. Furthermore, the engineer is looked upon as trustworthy when they give their assessment of the potential risk.

Notes

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