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Nothing Recedes Like Success - Risk Analysis and the Organizational Amplification of Risks

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Nothing Recedes Like Success? Risk Analysis and the Organizational Amplification of Risks*

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Introduction

The field of systematic risk assessment is still young, and as might be expected, many of the disciplines that most need to be brought into risk assessments are not yet fully represented. An area of particular weakness concerns the social sciences — those that focus on the systematic study of human behavior. To date, it has been common to assume that the "proper" roles for social science are limited to risk management[1] or risk communication.[2] The field has been much slower in drawing on social science expertise as a part of risk *assessment,* including the estimation of probabilities and consequences of hazard events. Unfortunately, as this paper will illustrate, this omission is one that is likely to lead to errors in the assessments — errors that are particularly pernicious because they are so often unforeseen.

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1 *E.g.*, NATIONAL RESEARCH COUNCIL, RISK ASSESSMENT IN THE FEDERAL GOVERNMENT: MANAGING THE PROCESS (1983).

2 NATIONAL RESEARCH COUNCIL, IMPROVING RISK COMMUNICATION (1989).

The focus of this paper will be on *technological* risks that are in some way *managed* by humans and their institutions (governments, corporations, communities) *over time* — particularly over relatively extended periods of years, decades, or even centuries. Problems are especially likely to emerge in connection with some of the very kinds of technological developments that have often provoked some of the greatest outcry from members of the general public. These are developments with high levels of what Slovic[3] has called "dread" potential, particularly the potential to produce massive *consequences* in the event of accidents, even though such accidents have often been judged by members of the risk analysis community to have only miniscule *probabilities* of occurrence. Such intense public reactions have, in the past, often inspired equally intense reactions, in turn, from members of the technical community, sometimes with the claim that the public is displaying "irrationality,"[4] and often with the complaint that such public perceptions are completely out of line with "real" risks. Increasingly, however, the field of risk assessment has been acknowledging that risk assessments are at best quite imperfect representations of "reality."[5] This paper will argue that, in the future, those of us who produce risk assessments will need to be still more circumspect in our readiness to believe the numbers we produce.

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3 Slovic, *Perception of Risk*, 236 SCIENCE 280 (1987).

4 DuPont, *The Nuclear Power Phobia*, Business Week 14 (Sept. 7, 1981); Cohen, *Criteria for Technology Acceptability*, 5 RISK ANALYSIS 1 (1985).

5 Clarke, *Politics and Bias in Risk Assessment*, 25 SOC. SCI. J. 155 (1988) [hereinafter *Politics and Bias*]; Clarke, *Explaining Choices Among Technological Risks*, 35 SOC. PROBLEMS 22 (1988) [hereinafter *Explaining Choices*]; FISCHHOFF, LICHTENSTEIN, SLOVIC, DERBY & KEENEY, ACCEPTABLE RISK (1981) [hereinafter ACCEPTABLE RISK]; Kasperson, Renn, Slovic, Brown, Emel, Goble, Kasperson & Ratick, *The Social Amplification of Risk: A Conceptual Framework*, 8 RISK ANALYSIS 177 (1988) [hereinafter *Social Amplification of Risk*]; Freudenburg, *Perceived Risk, Real Risk: Social Science and the Art of Probabilistic Risk Assessment*, 242 SCIENCE 44 (1988); Perrow, *The Habit of Courting Disaster*, The Nation 1 (Oct. 11, 1986).

Given the nature of this paper's focus, several caveats are in order. First, to say that probabilistic risk assessments may be deserving of less statistical confidence — and that the views of the general public may need to be seen with less scientific contempt — should not in any way be taken as implying that those of us who engage in risk assessment are in any way failing to "give it our best shot." Nothing in this paper should be taken as implying an accusation of conscious bias among risk assessment practitioners; to the contrary. Most practitioners generally do appear to be well intentioned, ethical, and professional individuals — many if not most of whom take pains to err, if at all, on the side of conservatism. The problems of the field appear not to be those of intention, but of omission. Second, while a listing of omissions and weaknesses is, by its nature, likely to be read as quite critical in tone, the criticisms expressed herein are explicitly intended to be constructive ones; they are being offered here in the interest of improving the field, not disbanding it.

Third, while the call of this paper is for the systematic use of social science in risk analysis, this should be seen as a natural extension of the truly significant gains and improvements that have already been made. Risk assessors, particularly in the past few years, have made important progress in considering potential complicating factors and in beginning to recognize the often-considerable uncertainty that often exists, particularly as assessments draw more heavily on expert opinion instead of empirical evidence. As a result of changes already made, many of the most glaring errors of early risk assessments are already well on their way to being corrected; the intention behind this paper is to contribute to a continuation of that process. Fourth and finally, to stress an earlier point, this paper focuses on *technological* risks that are *managed* by humans and their institutions *over time*. The logic reported here may or may not apply to other areas of risk assessment, such as dose extrapolation; further analysis and examination will be required before such decisions can be made.

Social Science in Risk Assessment

Persons with physical or biological science backgrounds often express surprise at the presence of social scientists in risk assessment, wondering aloud how such "nontechnical" fields could possibly contribute to the accurate assessment of risks. Aside from the fact that the social sciences are often highly technical — and scientific — the more straightforward response is that *human activities cannot be overlooked* by any field that hopes to be accurate in its assessments of risks, particularly in the case of technological risks.

At a minimum, humans and their organizations will enter into the arena of technological risks in at least two places — in the *assessing of risks* and in the *operation of risk-related systems*. The problems created by human fallibilities in the process of risk assessment — i.e., by what amounts to "'human error' in risk estimation techniques"[6] — have begun to be the focus of other publications.[7] The effort in this paper will be to bring greater analytical attention to the operation of risk-related systems — that is, to the management and operation of risk-related institutions over time.

Institutions, however, are more than just collections of individuals. One common problem for persons who do not have background or training in the social sciences — as well as for some who do — is the tendency to focus so strongly on *individual* motivations and behaviors that collective or *structural* factors are simply overlooked. While the assumption is rarely made explicit, the common fallacy is to assume that, when things go wrong, "it is because some individual screwed up," to quote a comment from a member of the audience at a recent risk conference.

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6 Freudenburg, *supra* note 5, at 45.

7 *E.g., Politics and Bias, supra* note 5; *Explaining Choices, supra* note 5; Clark & Majone, *The Critical Appraisal of Scientific Inquiries with Policy Implications,* 10 SCI., TECH. & HUMAN VALUES 6 (1985); Egan, *To Err Is Human Factors,* 85 TECH. REV. 23 (1982); ACCEPTABLE RISK, *supra* note 5.

Unfortunately like many assumptions, this one is plausible but often wrong. In fact, as sociologists in particular have long known, many of the most unfortunate outcomes in history have reflflected what Merton's classic article[8] termed the "unanticipated consequences of purposive social action." Problems, in short, can be created not just by individuals, but by institutions, and not just by volitions, but by situations.

The Organizational Amplification of Risks

Due in part to the publication of a paper on the topic by Kasperson and his associates[9] and in part to the practical significance of the topic, "the social amplification of risk" has begun to receive increasing attention in the risk analysis community. As the authors of that paper have carefully pointed out, what is at stake is the amplification of *risk,* not merely of risk *perceptions*. Their analysis noted the ways a given risk event can send "signals" to a broader community through such processes as becoming the focus of attention in the media. To date, however, there has been little analysis of the ways in which the probabilities of the initiating "risk events" themselves can be amplified by the very organizations and institutions having responsibility to operate a technology or regulate its safety.

While a great deal of attention has already gone into the conscious or volitional activities that can be undertaken to manage risks more successfully — and indeed, while it is probably the case that, in general, the net effect of such conscious attention to safety is to lessen the risks[10] — a far greater problem may exist with respect to aspects of organizational functioning that are unintended and/or unseen. At the risk of some oversimplification, organizational functioning will be discussed

8 Merton, *The Unanticipated Consequences of Purposive Social Action,* 1 AM. SOC. REV. 894 (1936).

9 *Social Amplification of Risk, supra* note 5.

10 *But see* Finkel, *Is Risk Assessment Really too Conservative? Revising the Revisionists,* 14 COLUM. J. ENVT'L L. 427 (1989).

here in terms of four sets of factors that have received insufficient attention in the literature to date. The four include individual-level human factors, organizational factors, the atrophy of vigilance, and the imbalanced distribution of institutional resources.

A. Individual-Level Failures and "Human Factors"

Three sets of individual-level human factors require attention — errors of individual culpability, errors that are predictable only in a more probabilistic sense, and the actions of persons who are external to the systems normally considered in risk assessments to date. The broad range of "human factors" that are traceable to the actions of organizations, rather than individuals, will be discussed in section B, below.

1. "Standard" human factors. "Human error" is a value-laden term, one that has often been used to describe situations that might more appropriately be blamed on mismatches between people and machinery.[11] In general, to the extent to which human behaviors have been considered in risk analyses to date, the focus generally has been on problems of individual workers, ranging from insufficient levels of capability (due to limited intelligence, inadequate training, and absence of necessary talents, etc.) to factors that are often associated with low levels of motivation (laziness, sloppiness, use of alcohol/drugs, etc.). As a rule, these individual-level human factors share three characteristics. First, they are commonly seen as the "fault" of the individual workers involved, rather than of any larger organizational systems.[12] Second, they tend by their nature to be preventable and/or correctable. Third, these kinds of "human error" are often identified by official investigations that are conducted after accidents and technological disasters, as having been key, underlying, causal

[11] Egan, *supra* note 7; Flynn, *The Local Impacts of Three Mile Island,* in PUBLIC REACTIONS TO NUCLEAR POWER: ARE THERE CRITICAL MASSES? 205 (W. Freudenburg & E. Rosa eds. 1984); Freudenburg, *supra* note 5.

[12] *E.g.*, Szasz, *Accident Proneness: The Career of an Ideological Concept,* 4 PSYCH. & SOCIAL THEORY 25 (1984).

factors.[13]

At the risk of emphasizing the obvious, it needs to be noted that the potential range and significance of human errors could scarcely be overemphasized—but can readily be overlooked. As the common saying has it, "It's hard to make anything idiot-proof — idiots are far too clever." The problem is particularly pernicious in the case of systems that are estimated to have extremely low probabilities of failure, as noted below. Given that these individual-level human factors receive at least some degree of attention in the existing risk literature, this paper will move instead to other categories of human behavior that appear to require greater attention in the future.

2. *"Stochastic" human factors.* Aside from the fact that certain individuals may indeed have insufficient capacities and/or motivations to perform the jobs they are expected to do, there is limited but growing evidence that many of the technological systems involving both humans and hardware are likely to encounter what might be called "stochastically predictable" problems. Even among workers who are intelligent, properly trained, and motivated, there is a potential for fatigue, negative responses to stress, occasional errors in judgments, or prosaically predictable "bad days." This category of problems can be described as "stochastically predictable" in that virtually anyone with even a modest familiarity with human behavior knows that an unfortunate event often "happens," as the recent bumper sticker puts it, but it is only possible in a statistical or probabilistic sense to "predict" the exact problem/mistake, the person committing that mistake, or the time of commission. Accidents are more likely to occur in the five hours after midnight than in the same number of hours before, for example, but beyond such statistical generalizations, the *specific* problems and their time(s) of occurrence appear to be almost completely chaotic or random.

[13] *E.g.*, U.S. OFFICE OF TECHNOLOGY ASSESSMENT, REPORT NO. OTA-SET-304, TRANSPORTATION OF HAZARDOUS MATERIALS (1986); D. GOLDING & A. WHITE, GUIDELINES ON THE SCOPE, CONTENT AND USE OF COMPREHENSIVE RISK ASSESSMENT IN THE MANAGEMENT OF HIGH LEVEL NUCLEAR WASTE TRANSPORTATION (1989).

If there is an exception, it is in the way in which much of the work in technological systems is structured. Intriguingly, it is possible that typical or "engineering" responses to this problem may tend in fact to make it worse: There may be something like a generic difficulty for humans in maintaining attentiveness to jobs that amount to little more than routine monitoring of the equipment that "runs" a system except in times of emergency — as in the kinds of jobs sometimes described, with reason, as involving "99% boredom and 1% sheer terror." Yet these are precisely the kinds of systems often developed in response to failures of human vigilance. The limited available research on human/technological systems that have avoided error more successfully, such as aircraft carriers,[14] generally suggests instead that most people do better if the systems they operate require them to remain attentive, even at the cost of considerable tension or pressure.

3. "External" human factors. As noted elsewhere[15] and occasionally considered at least in a qualitative way in risk assessments, problems can also be created by the actions of persons who are external to a technological system itself. The most commonly considered examples of "external" human factors have to do with terrorism and/or sabotage activities, whether instigated by disgruntled former employees, social movements that are opposed to a given technology, or other types of persons or groups. While the U.S. has been quite fortunate to date in avoiding most forms of overt terrorism, closer examination might reveal that the odds of such deliberate intrusions are too great to be safely ignored; the annual risk of terrorist activities at a controversial facility, for example, might be well over one in a hundred, rather than being less than one in a million.[16]

[14] Rochlin, LaPorte & Roberts, *The Self-Designing High Reliability Organization: Aircraft Carrier Flight Operations at Sea*, 40 NAVAL WAR C. R. 76 (1987).

[15] *E.g.*, Freudenburg, *supra* note 5.

[16] *Id. See also*, Holdren, *The Nuclear Power Controversy*, in PROCEEDINGS OF THE COLLOQUIUM ON THE SCIENCE COURT, 170, at 172 (1976).

Other kinds of "external" intervention may be even more likely; the possibilities range from acts of neighbors to acts of Congress. At least some observers have concluded that the infamous Love Canal incident, for example, was due not just to the actions by Hooker Chemical Company, which filled a trench with its waste chemicals, but also to later real estate and urban development. After filling the trench, Hooker Chemical covered the site with a layer of clay and then deeded it to the local school district for $1.00; it was after that time that construction and even excavation for homes and highways may have led to considerable water infiltration, which later led to the "leaking" of the chemicals from the waste site into neighborhood homes.[17]

Perhaps somewhere in the middle of the continuum of culpability, between deliberately malicious actions by terrorist groups and relatively naive actions by ignorant neighbors, would be actions that reflect political and/or economic motivations. A recent example is provided by the Nuclear Waste Policy Act of 1982,[18] which established a national policy for disposing high-level nuclear wastes, and which was passed only after a long, careful, and highly visible debate in the halls of Congress. Amendments to the Act, however, have been passed with much less public scrutiny and much more speed, largely due to the use of last-minute amendments to appropriations bills. The Nuclear Waste Policy Act Amendments of December 1987[19] "amended" the process of site selection to the extent of discarding the policy itself (studying three sites extensively before picking the best one). The new bill — described by the Governor of Nevada less formally as the "screw Nevada bill" — directed the U.S. Department of Energy (DOE) to proceed with the study of a specific site in Nevada, not even considering other sites until or unless the first site would be found to be unsuitable.

[17] For a fuller discussion, *see* A. LEVINE, LOVE CANAL: SCIENCE, POLITICS AND PEOPLE (1982).

[18] 42 U.S.C. §10101 et seq. (1988).

[19] 42 U.S.C. §§ 10101, 10172, and 10172a (1988).

In the next two Federal fiscal years, the Chair of the Senate Appropriations Subcommittee for Energy and Water Projects engineered further amendments, imposing severe constraints on what, under the original legislation, was supposed to have been an "independent" study program under the control of the State of Nevada. The appropriation for fiscal year 1989 — passed less than two weeks before the start of the state fiscal year to which it applied — cut by 50% the level of support for the study program that had already been negotiated between the state and DOE; the surprise amendment even named specific studies for which the state was forbidden to spend more than specified amounts.[20] The appropriation for fiscal year 1990 effectively cut even this reduced appropriation by roughly 90%. While one of the arguments for these cuts in Nevada's independent research capability was that the DOE was already carrying out a research program of the highest possible quality, the Secretary of Energy was later to reach a very different conclusion, announcing that his Department's research during the period covered by the amendments had been so seriously deficient that the entire research program essentially needed to be "started over."[21]

Against a backdrop such as this, it may not be prudent to assume that, where the safety of a facility or site will depend in part on actions to be taken by elected or appointed officials many years in the future, the policies in existence at the time when a risk assessment is done will be the policies actually followed at those future times. As a relatively straightforward illustration, imagine you are a Senator and the year is 2010. The Federal budget deficit is a major issue — still. Your constituents are demanding a variety of services, ranging from plans to build new jet-ports to the need for retirement/health care facilities for aging baby-boomers. You face a tough re-election campaign next year. Taxes are "already" too high — still. In this context, when an official

20 Wald, *Congress May Cut Waste Site Funds: Move Could Hurt Nevada Bid to Show It Is Unsuitable for the Nuclear Dump*, N.Y. Times, June 22, 1988, at A14.

21 Wald, *U.S. Will Start Over on Planning for Nevada Nuclear Waste Dump*, N.Y. Times, Nov. 29, 1989, at A.1.

from the future "Department of Environmental Remediation" testifies reluctantly that her agency will need an additional $82.5 billion "to fulfill a promise we made to the American people back in 1990" — for example, to clean up the messy results of a series of mistakes in a thinly populated western state — which would you choose to do: fulfill someone else's ancient promise to that far-away state, or fulfill your recent campaign promise to bring more jet-ports to your own? At a minimum, it appears, the likelihood of future fulfillment of promises should be taken as something less than a certainty; under many conditions, in fact, the probability may even prove to be under 50%. An assessment that fails to deal with the predictability of such problems is likely to prove no more realistic than one that ignores biological factors or assumes that water will normally run uphill.

B. Organizational Failures and "Organizational Factors"

In addition to the actions of individual humans, however, the actions of *organizations* can have a far greater influence on real risks than has been recognized in the risk assessment literature to date. Partly to preserve a symmetry with the common discussions of "human factors" — most of which have to do with characteristics of individuals — this paper will refer to this second set of considerations as "organizational factors." As will be noted, there are a number of ways in which such organizational factors need to be seen as *expected,* rather than as "excepted," for purposes of our analyses. It appears that our organizations are faced with a perplexing panoply of systematic organizational/institutional factors, the net result of which will be to increase, rather than decrease, the "real" risks posed by technological systems.

1. Organizational variations in commitment to risk management. Just as individuals can differ greatly in terms of personality, competence, motivation, and so forth, so too can organizations. Some organizations manage to operate nuclear power plants efficiently, safely, and with a high level of availability; others are less successful. Some organizations make a genuine commitment to worker safety and environmental protection; others do little more than go through the motions. All of this is hardly new information for the risk assessment community; unfortunately, it is information that is still too often ignored in our analyses. While informal discussions among risk specialists often center around the problems of organizations having less-than-impressive levels of commitment to safety and risk management, what shows up in the conversations often disappears from the calculations. Risk analyses tend to have difficulty quantifying the uncomfortable fact that organizations' standard operating procedures are sometimes more likely to be ignored than to be followed, particularly when it comes to procedures that are intended to improve the safety of an operation rather than to boost the rate of production.

This collective oversight is more than a matter of mere academic or incidental interest; in some cases, in fact, the lack of organizational commitment to risk management may be a *predominant* source of *real* risk. Particularly in the case of "technological" failures that have received widespread public attention, such organizational factors are so common that the field can no longer afford to ignore them — if indeed it ever could. To turn to some by-now familiar cases, the President's Commission on the Accident at Three Mile Island[22] began its investigation looking for problems of hardware, but wound up concluding the overall problem was one of humans — a pervasive "mind-set" in the nuclear industry at the time, reflecting a problem of organizational hubris that contributed substantially to the likelihood of accidents. At least according to some of the reports in the popular press, the accident at Chernobyl took place while the plant was operating with important safety systems disabled.[23] The explosion of the space shuttle

22 PRESIDENT'S COMMISSION ON THREE MILE ISLAND, THE NEED FOR CHANGE: THE LEGACY OF THREE MILE ISLAND (1979).

23 *E.g.*, Norman, *Chernobyl: Errors and Design Flaws*, 233 SCIENCE 1029 (1986); Fialka, *Soviets Blame Nuclear Disaster on Technicians*, Wall St. J., Aug. 18, 1986, at 23.

Challenger has been attributed in large part to the "push" at NASA, the space agency, for getting shuttle missions launched on a regular schedule.[24] The later accident with the *Exxon Valdez* has been described even by the Wall Street Journal as reflecting a relatively pervasive lack of concern by both Exxon and Alyeska with the companies' own risk management plans.[25]

This list could be expanded, but the purpose here is not to point fingers at specific cases of organizational failure; rather it is to raise the point that, if we wish our risk analyses to be guided by scientifically credible, empirical evidence, rather than by wishful thinking about the way the world "should" look, we cannot responsibly accept any risk analysis that treats such common problems of organizational errors as if they simply do not exist. If we make the apparently innocuous assumption that organizations will function "as envisioned" in official plans, we may actually be making one of the most unreasonable assumptions possible — a "best-case" assumption that may only apply to a tiny fraction of real-world organizations, doing even that only imperfectly and only part of the time.[26]

2. *Bureaucratic attenuation of information flows.* In addition to factors that may affect only some organizations, however, there are also factors that appear to influence virtually all organizations, particularly the larger ones. One of the simplest factors has to do with the attenuation of information flows. Consider a recent accident that "should not have occurred:" the explosion of the Space Shuttle *Challenger*. A number of investigations after the incident called attention to the fact that the people with technical know-how had expressed concern, sometimes

24 *See e.g.*, Vaughn, *Regulating Risk:Implications of the Challenger Accident*, 11 L. POL'Y 330 (1989).

25 McCoy, *Broken Promises: Alyeska Record Shows How Big Oil Neglected Alaskan Environment*, Wall St. J., July 6, 1989, at A1, A4; Marshall, *Valdez: The Predicted Oil Spill*, 244 SCIENCE 20 (1989).

26 L. Clarke, Organizational Foresight and the Exxon Oil Spill (1989) (unpublished paper, Department of Sociology, Rutgers University).

quite forcibly, about the potential dangers of launching the *Challenger* under low-temperature conditions, while the persons at the top of the organization reported never having heard anything about such concerns. These investigations, in turn, prompted any number of responses, most of which were variations on the question, "How could that be ?"

For anyone who has studied organizations, at least part of the answer is quite simple, and, while it does not rule out the possibility of irresponsibility, neither does it require us to conclude that any conscious cover-up actions were involved. The basic fact is that communication is always an imperfect process, and the greater the number of "links" in a communication chain, the greater the likelihood that important pieces of the information will fail to get through. The common illustration of rumor transmission provides an example: If a "secret" is whispered to one person, who then transmits it to another, who transmits it to still another, the message if often unrecognizable by the time it gets around the room. It is also possible to illustrate the problem quantitatively:[27] If we make the relatively generous assumption that there will be a 0.7 correlation between what any given person in an organization knows and what that same person's supervisor will know about the same issue, this means that just two organizational "links" would reduce the correlation between the specialists' understanding of a technology and their supervisors' to less than 0.5 ($0.7 \times 0.7 = 0.49$), and seven links would reduce the correlation to less than 0.1 ($0.7^7 = .082$).

In some organizations, moreover, the bureaucratic attenuation will be even more severe, particularly in the case of "bad news." While organizations may no longer literally follow the practice of executing the bearers of bad news, most people do not enjoy hearing bad news, and the disinclination to be confronted by discouraging words may be especially high in organizations characterized by a strong commitment to goals. Goal commitment is generally helpful or functional for an organization — it helps people to work harder and in a more coordinated

27 Freudenburg, *supra* note 5.

fashion, for example — but it tends to exacerbate an unfortunate problem with respect to risk management. "Don't tell me about problems," supervisors are sometimes heard to say, "Tell me what we can do about them." Unfortunately, in the case of many areas of risk management, what the organization *can* do about a risk is often something the organization would rather not do. To return to the *Challenger* accident, technicians who suspected there would be problems with the O-ring seals, particularly at low temperatures, could have suggested (and did) that the launch be delayed for warmer temperatures. Such a step, however, would have put the agency further behind in its ambitious launch schedule. Completely redesigning the problematic seals, as the agency later did, would have created both delays and costs of a magnitude that clearly would have been considered unacceptable — at least until after the agency experienced the unfortunate alternative. To make matters still worse, the voices of caution are often referring to accidents that *could* happen, not that *will* happen — to probabilities that are uncomfortably high rather than to those that are certainties. It is one thing to risk the wrath of one's goal-oriented superior when one is convinced that a given course of action will lead to disaster; it is quite another to risk acquiring the reputation as a person who cries "wolf" about a problem that may still have a 70% probability of not occurring. Overall, both the *Challenger* disaster and the broader body of experience with organizational behavior would tend to suggest that when the problems being identified are serious and unpopular, and when the available "solutions" are even less acceptable, the outcome is likely to be a systematic filtering of bad news and a corresponding "emphasis on the positive" in the news that is actually passed up the chain of command to superiors' superiors.

3. Diffraction of responsibility. In addition to creating a possibility that a given piece of known information will fail to get through, organizations can create a significant possibility that an important piece of information will remain unknown or unrecognized. In essence, complexity can help to create the organizational equivalent of Catch-22: The specialized division of responsibility creates not just the possibility that a single weak link will cause the entire "chain" to fail, but it also increases the possibility that one or more links will have been forgotten altogether. Not only is each office or division expected to do its job properly — to make its own "link" of the chain adequately strong — but each is freed of responsibility for other links of the chain. The common, if generally understandable excuse, becomes, "That's not my department."

The not-my-department problem appears likely to be especially severe in the very kinds of large and complex organizations that have been evolved to manage "advanced" technological systems. Catton[28] refers to what he calls "corporate gaps" in providing this account of Air New Zealand 901, a sightseeing flight that flew directly into the north face of Mount Erebus, an Antarctic volcano. While "pilot error" was the first explanation offered by authorities, the facts of the case proved to be more complex:[29]

> When the plane collided with the mountain, killing everyone on board, it was flying in clear air, beneath a cloud ceiling that diffused the daylight in a way that made the upward sloping white surface of the mountain directly ahead indistinguishable from the horizontal white expanse all five pairs of eyes in the plane's cockpit had every reason to suppose they were seeing. According to the destination coordinates the pilot had been given in his preflight briefing, they were on a safe route down the middle of ice-covered McMurdo Sound. Due to changed destination coordinates the airline's Navigation Section had inserted into the aircraft's computer, they were instead flying toward a point lying directly behind the mountain.

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28 Catton, Jr., *Emile Who and the Division of What?*, 28 SOC. PERSP. 251, 264 (1985).

29 P. MAHON, REPORT OF THE ROYAL COMMISSION TO INQUIRE INTO THE CRASH ON MOUNT EREBUS, ANTARCTICA OF A DC10 AIRCRAFT OPERATED BY AIR NEW ZEALAND LIMITED (1981).

> It was not the job of the person who had "corrected" a supposed error in the flight plan to notify the pilot that a change of coordinates had been made. It was not the computer programmer's job to inspect the pilot's navigation chart to see if his preflight briefing had agreed with the information going into the Inertial Navigation System computer. It was not the responsibility of the Williams field controller to ask the pilot whether his preflight briefing and his computer held the same information. It happened from the division of labor and it was nobody's fault. Two hundred fifty-seven lives fell through the cracks.

In fact, the diffraction of responsibility may be something close to a *generic* problem in the management of technological systems. Some cases appear to present examples, at least, of severe deficiencies, as in some of DOE's own investigations of the firms running its nuclear weapons facilities,[30] and in other cases, observers may detect something closer to a deliberate denial or abrogation of responsibility,[31] reacting to it with a form of indignation. While the widely scattered assignment of responsibility may create gaps that are technically "nobody's fault," after all, many observers will be likely to conclude that there was at least some conscious intent to free the individual actors or departments from bearing responsibility for the collective consequences of their combined actions.

The intent of the present discussion, however, is to point out that important considerations can "slip through the cracks" *un*intentionally, as well, and in two ways. First, given that the complexity of technological systems can make it virtually impossible to foresee all of the ways in which problems might arise, the obvious implication is that managers of the system may prove unable to assign responsibility for components of the system that might prove later to be crucial. Second, *the complexity of the organization itself* can create difficulties,

[30] *See* the summary in Wartzman, *Chain Reaction: Rockwell Bomb Plant is Repeatedly Accused of Poor Safety Record,* Wall St. J., Aug. 30, 1989, at A1.

[31] *Cf.* Bella, *Organizations and Systematic Distortions of Information,* 113 J. PROF. ISSUES ENGINEERING 117 (1987).

oversights, omissions, and lacunae of responsibilities. As the recently retired supervising engineer of a large project once explained to this author,[32]

> The damned plant has got so many ways of going wrong that *nobody* really knows what they all are, not even me. Back when I first started, if I worked on a car, I not only knew how my part of the system worked — I knew how the whole thing worked. On this project, we're lucky if the various teams even know how their own parts of the plant are supposed to work, and nobody but God Almighty really knows how the whole thing fits together.

4. *Loyalty, vulnerability and amplified risk-taking*. As Heimer[33] has noted, a number of less notorious but often still tragic industrial accidents have occurred when workers were taking risks that everyone, at least in retrospect, would agree the workers should not have been taking. As she correctly points out, the recurrent nature of this phenomenon suggests the utility of asking whether some underlying factors might be at work. Drawing on the significant literature on risk perceptions, which indicates that most people are extremely reluctant to take risks in pursuit of financial gain, she notes there is little reason to believe that the workers were taking such risks in hopes of increasing their salaries. Instead, she suggests, these workers were taking risks for much the same reason as many other people take risks — to avoid losses, in this case specifically including the "losses" represented by being laid off or fired.[34]

Note that it is decidedly *not* necessary for persons at the top of an organization to have issued orders to ignore or override safety concerns for persons lower in the organization to *behave as if* precisely such orders had been given. One of the basic assumptions of a corporate control structure of the U.S. model is that persons at the top of an

32 Private conversation; speaker prefers anonymity.

33 Heimer, *Social Structure, Psychology and the Estimation of Risk,* 14 ANN. REV. SOC. 491 (1988).

34 *Id.*

organization establish the policies, and those lower down have the responsibility of deciding how such policies and goals are to be brought to fruition. Excessively loyal subordinates, such as the Reagan administration's John Poindexter, may even go so far as to discern the value for their superiors of "plausible deniability" — the ability to say, if the need ever arises, that they had no awareness of the specific steps their subordinates were taking to implement their overall directives.[35]

While most observers seem to feel that the actions of John Poindexter were excessive, there is little debate about the value of loyal employees in general, particularly about those who "know what needs to be done, and do it without asking." In many cases — for example, in the face of the deadline or an impending storm — there literally may be no time to clear one's actions with supervisors before proceeding. *Even if no one in the organization has ever said the workers should take on unnecessary risks,* however, corporate leaders rarely complain about employees who do too much for the firm, more often voicing complaints about those who do too little. While such amplified risk-taking may be seen as desirable or deplorable, depending on the values of the observer, the point here is not so much *how* the pattern is seen, but rather that, for analytical purposes, it needs to be seen instead of ignored.

C. The Atrophy of Vigilance

At a still broader level of abstraction, there is a need to consider what would be expected to happen to organizational commitment to risk management *over time,* particularly in the case of rare or "unexpected" problems. Even in an organization with an above-average commitment to safety, and one where managers seek not to put pressure on workers to cut corners, it appears that the normal pattern will be for attentiveness and vigilance to atrophy over time. There are at least three key mechanisms behind this expectation — only one of which has to do with the predictability of complacency among individuals. At the

35 *Cf.* Bella, *supra* note 31.

organizational level, further problems are introduced by matters as mundane as cost controls and as unexpected as goal displacement.

1. Complacency and boredom. At least since the time when an iceberg got the best of the "unsinkable" *Titanic,* most ships' crews have presumably been operating at an increased level of caution and alertness for at least their first trips through iceberg-infested waters. Adrenaline, however, does not keep on pumping forever. While the ships coming in and out of the Alyeska pipeline terminal in Valdez admittedly had not been totally immune from problems, the *general* pattern of experiences up through 11:59 p.m. on March 23, 1989, scarcely would have raised concerns about catastrophic failure for most observers. Over 8,000 tankers had gone in and out of the port, over a period of more than a decade, without a single catastrophic failure. Based on the empirical track record up to that point, most observers presumably would have seen little reason for any particular concern.

Neither, unfortunately, did the crew of the *Exxon Valdez.* Five minutes later, however, the incredibly sophisticated tanker had an incredibly stupid encounter. Despite an array of navigational devices having a level of sophistication that early sailors could scarcely have imagined, the largest, newest, and best-equipped tanker owned by Exxon — one of the largest and most technologically sophisticated organizations in history — nevertheless managed to hit an obstacle that was literally miles out of its course and was marked by a flashing red light. The obstacle was also marked clearly on navigation charts, and it had been known by sailors for more than two centuries; the earliest sailors in the area had named it after the same Captain Bligh who was later to achieve a different kind of notoriety as the victim of a mutiny on the *HMS Bounty.* The accident, coincidentally, took place during the 200th anniversary year of the mutiny.

In many ways, the eras before and after the stroke of midnight on Good Friday, 1989 — years of reasonably successful operation, followed by the largest oil spill in U.S. history — could scarcely seem more disparate. In another sense, however, perhaps they could not have been more closely related. It is entirely possible that the accident of Good Friday, 1989, would not have occurred but for the tragic complacency engendered by the dozen good years that had passed before. More specifically, it may have been the very "success" of earlier trips in and out of Prince William Sound — literally thousands of them — that helped to make possible a situation where the captain had retired to his quarters, the ship was under the control of a third mate who would not have been expected by a formal risk assessment to be at the helm and the Coast Guard personnel on duty were not bothering to monitor even the lower-power radar screens that remained at their disposal after cost-cutting efforts of a few years earlier. In the wake of the reduced vigilance, however, some 11 million gallons of crude oil fouled nearly a thousand miles of once-pristine shoreline.

2. *"Non-productive" status of safety measures.* Virtually all institutions, public or private, are likely to face periodic pressures to control costs. The sources of pressure may include competition, a desire to increase profits, responses to cost overruns, political or other pressures to "cut down on waste and inefficiency," or simply a laudable desire to do more with less. Whatever the original source of the pressure or the nature of the organization, at least one of the responses is likely to be consistent: Organizations will generally seek to protect what they consider to be their core functions and to cut back on those they consider peripheral.

There is a tremendous range of variation across organizations in what the "core" functions are considered to be — from building cars to busting criminals — but there is virtually no organization for which increasing the safety of its *own* operations is the primary or central goal. Instead, protection of health, safety and the environment tend to be secondary or "while" concerns: Organizations seek to produce energy "while" protecting the environment, operate submarines while providing an adequate level of protection for the crew, dispose of wastes "in an environmentally acceptable manner," and so forth. Almost never is risk management included in the first half of the sentence, at least in the description of overall organizational goals, as in "increasing the level of safety for workers and nearby communities 'while' maintaining adequate profit margins" — unless it is when risk management professionals use such terminology in the attempt to increase their organizations' attentiveness to issues of risk and safety.

The consequences of occupying organizationally peripheral positions, unfortunately, also show up in ways that are not just linguistic. To return to the *Exxon Valdez,* a series of reports in major news outlets[36] reveal what can happen. From one report:[37]

> Dozens of interviews with former officials and safety officers, along with a study of state records and original contingency proposals, indicate that a plan to avert a tanker disaster was developed a decade ago and then gradually dismantled piece by piece. ... Factors include
>
> • Rejection by the Coast Guard and Alyeska Pipeline Service Company. . . of a 1976 state study that forecast tanker accidents and urged such requirements as double-hulled tankers and tug boat escort beyond Bligh Reef....
>
> • Two cutbacks in recent years that probably removed an extra pair of eyes that might have spotted the off-course Valdez. In 1978, the Coast Guard reduced the distance that local pilots had to guide departing tankers and, since 1984, the Coast Guard has cut its radar staff in Valdez to 36 from 60, reduced the radar wattage and decreased the distance required for radar monitoring....
>
> • Disbandment in 1982 of the Emergency Response Team for Alyeska. ... Spill-fighting equipment on hand was below the minimum required; even the barge designated to carry containment booms and supplies was in dry dock. ...
>
> • Carelessness by the state agency charged with keeping Alyeska in compliance. The crash in oil prices in 1986

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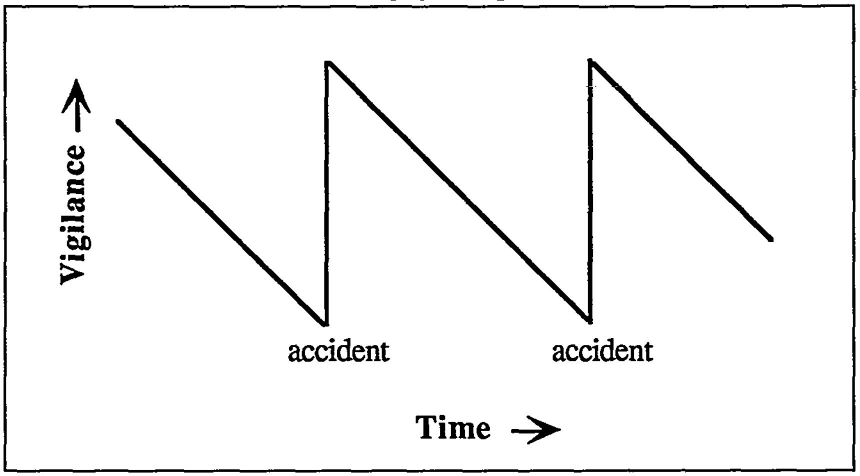
36 *E.g.*, Bartimus, Spencer, Foster & McCartney, *Greed, Neglect Primed Oil Spill,* St. Louis Post-Dispatch, Apr. 9, 1989, at 1, 15 [hereinafter *Greed, Neglect Primed Oil Spill*]; Church, *The Big Spill: Bred from Complacency, the Valdez Fiasco goes from Bad to Worse to Worst Possible,* Time 38 (Apr. 10, 1989).

37 *Greed, Neglect Primed Oil Spill, supra* note 36.

forced state budget cuts that reduced the work week at the Department of Environmental Conservation to 4 days.

Figure 1
The Atrophy of Vigilance



While this is only an example, it does illustrate at least two main points. First, there is more than a little irony in the fact that, if some organization's risk management activities had succeeded in averting the disaster, no one would ever have "known." In the absence of disaster, in fact, risk-management functions often seem to be superfluous; only the *occurrence* of a disaster provides incontrovertible proof that disaster-prevention activities are "necessary." Rather than suggesting that risk-management functions will generally receive the resources they "need," in fact, incidents such as the *Exxon Valdez* suggest a much more disquieting possibility: In the absence of truly frightening "close calls," or even in cases where close calls occur but are interpreted to mean that current measures "worked" and no further measures need to be taken,[38] perhaps the general tendency of organizations is to cut back

[38] Bier & Mosleh, *The Analysis of Accident Precursors and Near Misses: Implications for Risk Assessment and Risk Management*, 27 RELIABILITY ENGINEERING & SYSTEM SAFETY 91 (1990); Tamuz, When Close Calls Count: Enhancing Organizational Learning About Risk, Presented at annual meeting of

on risk-management expenditures until an accident provides proof that the cuts were too severe. Figure 1 provides a schematic representation of the logic being suggested here.

Second, no "magic solutions" may be available. Neither a straightforward reliance on "private enterprise" (Exxon) nor on "public servants" (state, federal agencies) would appear to offer reason for complacency. Both private- and public-sector actors cut "unnecessary" costs for risk-management activities that might have helped to avert the disaster. Alyeska Pipeline Service Company, the consortium of the oil companies that runs the pipeline, might be expected by the uninitiated to provide a somewhat higher level of commitment to risk management, in that its employees would be administratively removed at least to some degree from the "pressures for profit" that would be more likely to characterize the oil companies themselves. If anything, however, Alyeska has come in for harsher criticism than Exxon itself. This may not be entirely accidental; in the words of one resident of southeast Alaska (a critic of both Exxon and Alyeska), "Alyeska isn't the place where any of the oil companies send their best people. You're never going to become the president of your company by way of working for Alyeska." It may also be worth noting in this context that corporate presidents often come from sales, production or even legal or accounting branches of a firm, but rarely if ever from the in-house office of risk management.

3. Displacement and routinization. As if to make matters still worse, virtually all organizations also have some difficulty with means/ends reversals and goal displacement: Whether a division of an organization was set up originally to protect health, clean up pollution, or find and develop oil reserves profitably, the persons in that division often come, over time, to devote an increasing share of their attention to "bureaucratic" concerns. Over time, in other words, the "real" goals of a department can come to focus on what were once seen simply as means to an end — on increasing the size of the departmental budget, for example, or on attempting to purchase new equipment for a given office. A second form of displacement takes place when organizational accounting comes to focus on *resources expended* rather than results accomplished: Particularly in government agencies having hard-to-measure goals, such as "improving health care for the aged" or "protecting the public health and welfare," an emphasis on accountability often becomes an emphasis instead on accounting measures — number of clients seen, rather than the improvement of health for each, or number of regulations issued, rather than improvements in the actual level of operating safety of power plants, transportation systems, and the like. While the problem of displacement is well-known in studies of organizations and in evaluation research, it has not yet received proper attention in risk analysis, particularly with respect to systems whose safety is likely to depend in part on the exercise of long-term vigilance by future organizations.

A particularly important form of means/ends displacement has to do with the importance of routinization — particularly in cases where we are trying to predict organizational responses to the accidents that do indeed occur. Problems are likely to be especially severe for the accidents that are the "least routine" or most rare — specifically including the implementation of contingency plans for low-probability events.

In the case of the Alaska oil spill, the "drills" on emergency preparedness conducted before the spill might have suggested to astute observers the need for greater attention to spill response. Neither the equipment nor the organizations worked as planned, and the drills "sometimes were near-disasters themselves."[39] Such lessons, however, were evidently overlooked. As Clarke[40] has cogently noted, at least five contingency plans were in effect at the time of the spill.

39 McCoy, *Broken Promises: Alyeska Record Shows How Big Oil Neglected Alaskan Environment,* Wall St. J., July 6, 1989, at A1, A4.

40 Clarke, *supra* note 26.

Among other commonalities, each envisioned not only that rescue and response equipment would be at the ready, but also that materials would be deployed in a carefully coordinated manner, with "an efficient and effective division of labor among organizations" being instituted almost immediately. At least in the plans, communication channels among previously competitive or even adversarial organizations would be established readily, interpretations of the communications would be unproblematic, and each organization or agency would take precisely the right step at precisely the right time to fit the need of other organizations.

The reality, of course, could scarcely have been less similar to the plans. Confusion seems to have been far more commonplace than communication; a number of important steps either failed to be taken or else fell through the interorganizational cracks. Rather than coordinating their activities as effectively as the components of a well-designed computer program, the various organizations with a stake in the spill and the clean-up often seemed to have more interest in blaming one another than in working with one another. Particularly during the critical, first few days, virtually the only effective response to the spill came not from any of the organizations having contingency plans, but from the fishermen of the region; rather than worrying about which organization or office ought to take responsibility for what, the fishermen essentially ignored such bureaucratic niceties and went to work — locating oil "booms" in Norway, arranging to have them transported to Cordova, Alaska, and then coordinating their deployment to protect critical hatchery and habitat areas. In short, the fishermen may have responded more effectively, even without the benefits of established plans and experience in emergency drills, than organizational actors who not only had such benefits but also access to far greater financial resources.[41]

As Clarke suggests, it may not have been an accident that the most effective early response to the spill came from outside of established

41 *See* the fuller discussion in Clarke, *supra* note 26.

organizations. Rather than indicating a "lack" of organization, Clarke suggests, the ineffective response to the spill from Exxon, Alyeska, and state and federal agencies may in fact reflect a case of "over-organization:"[42]

> One of the reasons we build organizations is to simplify decisions. It is in the nature of organizations to institute routines for handling decisions. These routines then become the templates through which organizations filter information, and hence organize action. Organizations are, in fact, organized to be inflexible. This means that organizations are organized to do some things well and other things poorly. ... Exxon is well-prepared for Arctic exploration, oil management, and political influence. It is less well-prepared for crisis management. ... If organizations were infinitely flexible, they would generally be ineffective in day-to-day operations.

Clarke's point is a critically important one, and readers are urged to reflect on its applicability to familiar organizational contexts. Virtually all of the persons within an organization are likely to have complained at some time of being "overworked," or of having too many demands placed upon them, relative to the resources with which they are provided. In fact, it is essentially part of the job description of an efficient manager to get the department to do more with less; if complaints of overwork are *not* forthcoming, some observers would take this as indicating that the manager might not be pushing the department hard enough. When the available resources provide "not quite enough to go around," however, the best guess is that functions seen by the department as less central or more peripheral — such as keeping oil spill clean-up equipment at the ready, as opposed to filling the oil tankers quickly — will be among the first to slip.

Like the research scientist who "already has enough to do" when a departmental chair suggests the instigation of a new research project, the various branches of an organization are likely to feel they are already

42 Clarke, *supra* note 26, at 26–27.

fully committed when a new challenge suddenly bursts on the scene. Firemen may (or may not) be ready for the unexpected when it occurs, patiently waiting for the opportunity to deal with the next fire or emergency, but few other organizations or persons would be likely to fit such a description. When new challenges and emergencies do arise, moreover, they are likely to be viewed not just with an eye to the organization's stated goals, but also with an eye to the implications for next year's budget, for the ongoing turf wars with competing or complementary organizations, and/or for the question of what other person or division might be induced to take on the added workload instead.

D. Imbalances in the Distribution of Institutional Resources

Still other factors that have largely been overlooked in past work have to do with the unequal distribution of and access to resources. Two factors appear to have important if generally unforeseen implications for risk management.

1. Mismatches between opposing sides. Persons in the risk policy community may often feel beleaguered and outnumbered, given the presence of unflattering media coverage on one side and often-hostile public groups on another. A number of the publications in the field make reference to this problem, although generally without providing specifics. Douglas and Wildavasky,[43] for example, claim that local opposition groups "are difficult to defeat because there are so many of them and they do not stay in one place."

A closer look at the facts, however, suggests that the imbalance of resources actually works strongly to the favor of industrial interests and "the risk establishment."[44] In terms of financial resources, many of the industries that have been the focus of the most intense public outcry on risk issues — nuclear power, offshore oil development, and waste disposal, among others — control vast financial resources. Meanwhile,

43 M. DOUGLAS & A. WILDAVASKY, RISK AND CULTURE: AN ESSAY ON THE SELECTION OF TECHNOLOGICAL AND ENVIRONMENTAL DANGERS 172 (1982).

44 T. DIETZ & R. RYCROFT, THE RISK PROFESSIONALS (1988).

the citizen groups that organize to oppose such developments — the greatly feared "NIMBY" or "Not In My Back Yard" groups — are generally in a position of needing to raise revenues through modest activities such as bake sales and car washes.

When it comes to the control of scientific resources, in particular, the resource advantage of industrial interests is virtually complete. A large number of scientists already work for industrial employers, often on a full-time basis. Yet, there are virtually no citizen groups, except at the national level, that can afford to hire even one scientist on a full-time basis. Even then, scientists working for national environmental or public-interest groups have often done so partly out of a sense of commitment and receive levels of pay significantly lower than would be commonly available to persons of comparable training and experience in private industry.

As Dietz and his colleagues[45] point out, this imbalance of resources may prove to have particularly important consequences to the extent to which the risk-management debate follows the adversarial model of decision making: If a quantitative risk assessment is performed on a large and profitable industrial enterprise such as the development and transport of oil, we can be reasonably sure that the industry involved will have the necessary scientific resources to scrutinize the assessment and point out ways in which the calculations may have resulted in a risk estimate that is "too high," but it will be a rare citizens' group, indeed, with the resources necessary to do a complementary technical analysis to identify errors leading to a risk estimate that is "too low." In short, despite risk assessors' best efforts to be "conservative," errors and omissions may mean that calculated risk estimates will still wind up being *insufficiently* conservative to reflect empirical reality.

2. Limitations on the roles performed by neutral parties. If there is indeed a David-versus-Goliath mismatch in resources between the

[45] Dietz, Frey & Rosa, *Risk, Technology and Society*, in HANDBOOK OF ENVIRONMENTAL SOCIOLOGY (R. Dunlap & W. Michelson eds. forthcoming).

opponents and proponents of new industrial developments, this would appear to place far greater importance on the role played by parties that might ordinarily be expected to be "in the middle." Three such sets of actors can be identified readily: The media, government agencies, and "independent" sources of expertise, such as universities and some research institutes.

Media coverage often seems to scientists to be "anti-science" in its orientation, but studies that have actually documented the nature and extent of coverage generally wind up finding no empirical evidence to support the presumed bias.[46] Aside from the fact that most studies show media coverage to have little effect on public views, beyond helping to "set the public agenda,"[47] a number of authors have concluded that the actual direction of media bias is pro-industry, not anti-industry.[48] Overall, it appears that environmental or safety-oriented groups may have an advantage in some respects — colorful representatives, or the David-versus-Goliath "angle," for example — but that these advantages are probably more than counterbalanced by the advantages and resources available to industry groups. The latter include the availability of lobbyists and full-time public relations personnel, the ability to spend large sums of money on advertising, and the fact that industry groups are "repeat players" rather than "one-shotters".[49]

[46] *E.g.*, PRESIDENT'S COMMISSION ON THREE MILE ISLAND, *supra* note 22; *see also* P. TICHENOR, G. DONOHUE & C. OLIEN, COMMUNITY CONFLICT AND THE PRESS (1980); Tyler & Cook, *The Mass Media and Judgments of Risk: Distinguishing Impact on Personal and Societal Level Judgments*, 47 J. PERSONALITY & SOC. PSYCH. 693 (1984).

[47] Kraus & Davis, *Political Debates*, in HANDBOOK OF POLITICAL COMMUNICATION 273 (D. Nimmo & K. Sanders eds. 1981); McCombs, *The Agenda-Setting Approach*, *id.*, 121-40; *but see also*, A. MAZUR, THE DYNAMICS OF TECHNICAL CONTROVERSY (1981).

[48] Molotch, *Oil in Santa Barbara and Power in America*, 40 SOC. INQUIRY 131 (1970), Molotch, *Media and Movements*, in THE DYNAMICS OF SOCIAL MOVEMENTS 71 (M. Zald & J. McCarthy eds. 1979); E. HERMAN & N. CHOMSKY, THE MANUFACTURE OF CONSENT: THE POLITICAL ECONOMY OF THE MASS MEDIA (1988).

[49] Galanter, *Why the 'Haves' Come Out Ahead*, 9 L. & SOC'Y REV. 95 (1974).

Industrial representatives are more likely to have pre-existing relationships with persons who work in the media, to be accessible to reporters who have time to make only one quick telephone call before a deadline, and to have at least a degree of presumed legitimacy as spokespersons who, whatever their faults or biases, tend to be well-informed on the issues that are of concern to them.[50]

Government agencies are certainly no strangers to the imposition of excessive, arbitrary, or overly burdensome regulations, and so in that sense, they would indeed seem to qualify as neutral parties — indeed, at times, they may also seem to be distinctly anti-industry in their actions and orientations. In a broader perspective, however, government agencies are more commonly seen by organizational analysts as subject to "capture" by the industries they are set up to regulate.[51] Criticisms range from the "revolving door" argument — the claim that too many officials wind up moving back and forth between jobs in regulatory agencies and jobs in the industries they regulate, usually with the latter being at higher salaries — to the fact that regulators simply spend much of their "public" interaction time in meeting with persons from the regulated industries, who after all would have an interest in making sure that the regulators are fully aware of the ways in which regulations are seen by the industry, rather than in dealing with members of the broader public.[52] Yet, there may also be problems that are far more subtle than outright "capture."[53] A regulatory agency is often forced to come up with a specific number (or level of exposure) to be treated as the dividing line between "safe" and "unsafe." As risk assessors are well

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50 Stallings, *Media Disclosure and the Social Construction of Risk*, 37 SOC. PROBS. 80 (1990).

51 *Cf.* A. SCHNAIBERG, THE ENVIRONMENT: FROM SURPLUS TO SCARCITY (1980); G. MCCONNELL, PRIVATE POWER AND AMERICAN DEMOCRACY (1970).

52 *Cf.* Friesema & Culhane, *Social Impacts, Politics, and the Environmental Impact Statement Process*, 16 NAT. RES. J. 339 (1976).

53 Freudenburg & Pastor, *Public Responses to Technological Risks: Toward a Sociological Perspective*, SOCIOLOGICAL Q. (forthcoming).

aware, however, science rarely provides such neat dividing lines. An industry's costs of complying with regulations can often be stated with at least apparent precision, but the "best" level of protection is almost always open to debate. While many citizens hope that agencies would give "the benefit of a doubt" to the protection of public health and safety in cases where the evidence is ambiguous and the experts are in disagreement, the agencies are likely to face considerable (and effective) pressure from affected industries not to impose regulations unless they can be shown to be *un*ambiguously justified.

Nor can *university-based scientists* be considered immune to criticism. While this paper itself can be taken as an illustration of the fact that scientists employed in academic settings have considerable freedom to develop and then express the kinds of analyses that may be expected to be unpopular with industrial interests — the paper having been written by a tenured professor with a "hard-money appointment" at a Big-Ten university — a number of important analyses have concluded that, on balance, even the scientists who work in university settings are significantly more likely to be supportive of industrial interests than critical of them. In particular, Schnaiberg[54] has noted that the "production" sciences (those that help industries to produce or to compete more profitably or efficiently) tend to receive far higher levels of support than do the "impact" sciences, namely those that examine the potentially negative social or environmental impacts likely to be created by the development of such technologies.[55]

The production/impact investment imbalance is not merely a matter of corporate support for science, moreover, but includes as well the support from federal agencies such as the U.S. Department of Agriculture or even the National Science Foundation. The disparity in levels of funding is almost invariably on the order of 20:1 or more, and

54 A. SCHNAIBERG, *supra* note 51.

55 *See also* J. KLOPPENBURG, FIRST THE SEED: THE POLITICAL ECONOMY OF BIOTECHNOLOGY 1492–2000 (1988).

the average disparity may in fact be closer to the order of 100:1. At least according to Schnaiberg's analysis, scientists who are naturally attuned to doing "production" science will generally tend to receive far higher levels of funding than "impact" scientists *of equal scientific competence,* will be able to support or produce larger numbers of graduate students, will have larger and better-equipped laboratories, and in general, will be able to do what appears to be (and may actually be) "better science." Under the assumption that most scientists-in-training are rational people who want to be able to do good science, it follows that even university-based scientific departments, over time, will do a far better job of promoting and rewarding the performance of scientific research that advances industrial interests than of the otherwise equally "worthwhile" science that would deal with concerns likely to be raised by the opponents of a technology.

Concluding Thoughts: Biasing Pressures, Seen and Unseen

At the risk of stressing the obvious, literally all of the factors thus far identified in this paper are of the sort that would be expected to lead to the underestimation of "real risks" *even by scientists who are well-meaning, honest, and not aware of any pressures to produce biased results.* Those of us who work for "establishment" organizations often criticize the objectivity of critics who work for environmental or "public interest" groups, arguing that the political positions and interests of such groups may have influenced the findings and the arguments of the scientists they employ; but, if there is a potential for biasing pressures in one direction, there may also be similar pressures in the other direction. Given that scientists are far more likely to work for industrial interests than for groups of opponents, as noted above, the "tangible" pressures toward bias may make the problem worse.

At the risk of offering another observation that "everybody already knows," the real world is often not so free from "unscientific" pressures on scientists as we might like. Perrow[56] provides a relatively critical examination of cases where industrial representatives have understated known risks.[57] The publications of environmental groups often focus heavily on cases in which industrial or governmental representatives have lied about or covered up credible evidence about risks to the public health and safety. While such organizations would presumably have an interest in encouraging a high or even exaggerated sense of the likelihood or frequency of such incidents, recent examples of "unfortunate" organizational behaviors originally brought to broader attention through the efforts of such activist groups include the Federal Bureau of Investigation (FBI) probe of DOE's facility at Rocky Flats, Colorado, resulting eventually in a raid on the facility by federal enforcement agents and the filing of criminal charges. Discussions of such problems in the risk assessment literature are understandably rare,[58] and yet the problems may be too significant to ignore.

The point here, however, is not to dwell on such clear-cut cases of unscientific behavior by scientists, regrettable though each of them may be. Instead, it is to note that this entire paper has been written from the perspective of a loyal member of the risk assessment community, one who not only wishes to minimize the likelihood of such unprofessional behaviors by scientists but who also believes, on the basis of first-hand observations, that the vast majority of scientists are indeed careful, honest and scrupulous, often to a fault. The problem, in short, is not

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56 Perrow, *The Habit of Courting Disaster*, The Nation 1 (Oct. 11, 1986).

57 *See also Politics and Bias, supra* note 5; *Explaining Choices, supra* note 5; Freudenburg, *Risk and Recreancy: Weber, the Division of Labor, and the Rationality of Risk Perceptions*, presented at the 12th annual Department of Energy Conference on Low-Level Radioactive Waste, Chicago, August 1990; Sterling & Arundel, *Are Regulations Needed to Hold Experts Accountable for Contributing 'Biased' Briefs of Reports that Affect Public Policies?*, in RISK ANALYSIS IN THE PRIVATE SECTOR 285 (C. Whipple & V. Covello eds. 1985); Stoffle, Traugott, Harshbarger, Jensen, Evans & Drury, *Risk Perception Shadows: The Superconducting Super Collider in Michigan*, 10 PRACTICING ANTHROPOLOGY 6 (1988).

58 *But see* Sterling & Arundel, *supra* note 57.

that the scientists involved in risk assessment are bad or biased people; in general, they clearly are not.

Unfortunately, the problems identified in this paper are in some ways more serious, and more difficult to counteract, than would be the case if deliberate or even conscious sources of bias were in fact involved. Instead, the problem is in a variety of more subtle factors — unseen and unfelt, yet unfortunate in their consequences. These organizational and institutional factors exert an influence that could scarcely be more disturbing were deliberate malice actually involved. Systematically and repeatedly, these factors serve to *amplify the "real risks"* we seek to foresee and manage. Given that the field of risk assessment is committed to doing the best job possible in assessing risks accurately and fairly, such a systematic set of biasing factors is one we can no longer afford to ignore — if indeed we ever could.