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17

On the Design and Management of Nearly Error-Free Organizational Control Systems

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Todd R. La Porte

The accident at the Three Mile Island nuclear plant dramatically focused attention on the danger inherent in the operation of all large-scale, complex, and potentially hazardous technologies—that is, that the combination of machine and operator performance will fall below the expected level of reliability and pose a threat to public health and safety. That possibility poses critical problems for a contemporary U.S. society that is increasingly dependent on high-benefit/unacceptable-damage technologies. When risks regarded as wholly unacceptable are associated with the wide use of a technology rich in benefits, what is required to ensure extraordinarily reliable and safe operations if the technology continues to be deployed? And what are the long-term social and political consequences—for individuals, institutions, regions, and nations—of seeking to achieve such a system?

The promised benefit of the nuclear-energy economy is a certain supply of electrical power for at least 200 and possibly as many as 2000 years.[1] Poised against this is the unacceptable risk of inadvertent releases of radioactive materials in doses large enough to significantly increase the incidence of cancer and genetic damage.

The central hazard—the escape of radioactive materials—is present throughout the entire nuclear-fuel cycle, from the mining of uranium to the disposal of wastes (National Academy of Sciences [NAS] 1976, 1979b). Similarly, the challenges to organizational design and our processes of regulation issue from the whole range of activities associated with both civilian and military uses of nuclear materials. However, the production and waste-management phases of the fuel cycle exhibit somewhat different risk characteristics. Table 17.1 identifies characteristics that are particularly salient for social analysis.

The industrial processes for producing energy from radioactive materials require the use of nuclear fuels that can produce very high temperatures in order to generate high-pressure steam. There is no analogous process for the

TABLE 17.1

Contrasting Properties and Risk Characteristics in the Production and Waste Disposal of Radioactive Materials

	Production	Waste Management
Peaked, catastrophic release potential	Higher	Lower
Long term, accreted release potential	Lower	Higher
Organizational complexity	Higher	Lower (w/o reprocessing)*
Time span of watchfulness	Shorter (200-2000 yrs.)	Longer (1000-100,000 yrs.)
Lag in error recognition	Short	Long or very long
Costs of ameliorating the consequences of significant error	Prohibitive	Prohibitive

*With reprocessing, and waste solidification, the level of organizational complexity increases markedly.

treatment of radioactive wastes; consequently, there is a much lower probability of a catastrophic release of dangerous materials in the latter phase of the cycle. If radioactive waste management is effective, there should be little or no accumulation of wastes on the ground, at least not in the next 10-50 years. However, after wastes have been buried, there could be a dissolution of radioactive materials from their solidified form, and accumulations could be dangerous if they entered underground water supplies.

Very different levels of organizational complexity characterize each of the phases. The production phase, which includes uranium enrichment, fuel fabrication, and burning in large industrial power plants, demands a much higher level of technical and social complexity than the relatively straightforward

disposal phase, in which spent fuel is transported and entombed in deep geological repositories. This difference is substantially reduced when spent fuel is reprocessed for use as fresh fuel. The industrial processes used to recover unburned uranium and plutonium significantly increase the complexity of the overall system (U.S., Department of Energy [U.S., DOE] 1979, pp. 3.1.186-3.1.214 and Appendix L).

Nuclear materials have very long lifetimes—some ranging beyond 100,000 years.[2] Thus the period of watchfulness with regard to managing radioactive wastes extends far into the future. In the production phases of nuclear power, special care is necessary for a much shorter time—though it may be quite a long time in administrative terms. How long depends on the reserves of uranium and/or the extent to which reprocessing and the fast breeder-reactor are used. At a minimum, we are committed to watchfulness in the aboveground production phase for about 100 years—that is, the 60-70 year lifetime of the reactors scheduled to be completed in the next 10-20 years, plus the decade or so needed to decommission them and completely dispose of the wastes. Reprocessing and the deployment of fast breeder-reactors could extend this period to the next 2000 years and involve as many as 1500 reactors, ten times the 150 now thought to be the likely minimum (Interagency Review Group [IRG] 1979). Because of the very long period of radioactive hazard that exists after wastes are buried (approximately 80-100 years), significant errors in waste disposal might not be recognized until the more distant future. Errors in the production of energy (for example, TMI) provide much more rapid feedback. The potential costs of both kinds of error could be enormous.

A significant error can be defined as either a large single release or minor multiple and accumulating releases of radioactive materials that cannot be recovered. For both phases of the nuclear-fuel cycle, the perceived consequences of significant error are increasingly judged to be wholly unacceptable. That is, there is a growing belief that any error that results in a significant release of radioactivity might have such serious consequences that making an error is unacceptable (Mitchell 1979; Hohenemser, Kasperson, and Kates 1977).

This perception of the consequences of errors involving radioactive materials has two far-reaching implications. First, it reduces the acceptability of trial-and-error learning as a procedure for improving policy and operations in the nuclear industry and requires *decisions without feedback.* Second, it increases the demand for developing nearly error-free managerial and operational systems for nuclear technologies and requires *trials without error.* Such systems would be required for the duration of the unacceptable risk as a condition of continuing to use the technologies that are thought to be the source of the risk. When the management of radioactive wastes is included in the problems of handling nuclear materials, as it logically should be, both the time scales and scope of the problems are greatly extended. Thus, there are increasing demands that errors or lapses in operational performance be minimized even at the earliest, most experimental stages.

Decisions Without Feedback

Within the past three decades, a slowly maturing science of decision making has improved our understanding of information processing, the social psychology of decision makers, and the limitations of organizational behavior (White 1975; Steinbrunner 1974; Simon 1970; March and Simon 1958; and Braybrooke and Lindbloom 1963). In complex situations, the most effective, least error-prone strategy for decision making is an incremental, trial-and-error method of policy development. This strategy is characterized by continual changes in the direction of recent policies, responsiveness to confirming or dissenting signals from those most affected and a readiness to alter existing policies to rectify errors due to miscalculation or ignorance. This approach trusts the efficacy of error correction through feedback from customers and a pluralistic, representative political system. The alternative strategy, based on comprehensively analyzed plans, requires a level of detail and scope that may be impossible to attain for the nuclear industry.

The incremental approach is best suited to slowly changing situations in which errors can be quickly identified and in which the consequences of errors can be remedied at reasonable cost or are acceptable because of greater benefits. As these conditions become difficult to meet, the utility of the incremental approach diminishes. Thus, when relatively rapid change is believed to be necessary, when it will take a long time to recognize errors, and when the consequences of error are believed too costly to countenance, our established processes of policy development falter; they are no longer an effective means of arriving at decisions that can win the support that is necessary to legitimate and implement them (Lustick 1980).

Uncertainties about nuclear safeguards, waste storage, and plant operations have led to the growing conviction that the consequences of errors involving nuclear materials are too serious to tolerate; this conviction severely limits the utility of the incremental approach in the development of policies for nuclear energy.[3] In effect, we have lost confidence in the trial-and-error method as a way to learn about and improve the *overall* performance of either large-scale nuclear-power plants or a mature system of radioactive-waste management.[4] Some kinds of mistakes could result in substantial damage and be expensive to mitigate. Other mistakes will be discovered so late that correction will be impossible. In essence, when an error is observed on the basis of the first trial, it is already too late to remedy the problem (NAS 1979a). Improvement is impossible: The severity of consequences renders errors useless as a basis for improvement.

This presentation of the decision-making problems associated with radioactive materials illustrates the extraordinary analytical demands required to solve the dilemma. Insofar as a society foregoes trial-and-error learning in particular areas, it will be necessary to develop alternative methods of creating sound policy, thereby requiring more detailed knowledge of the phenomena involved before any action is taken. At a minimum, an alternative method will demand a much improved understanding of technological complexity, organizational scale, error detecting and rectifying systems, and management control systems and their effects on the long-term reliability of plant operations and the management of waste-processing facilities. In effect, we are pressed to approximate a comprehensively analyzed plan. This strategy is recognized to be difficult (if not impossible) to effect with high degrees of completeness (Braybrooke and Lindbloom 1963). Nonetheless, this is the approach being used to provide the detailed analysis necessary to ensure the security of bomb-grade nuclear materials and the escape-proof burial of nuclear wastes (Wohlstetter et al. 1979; NAS 1979a; IRG 1979). Thus far, such analysis has only occasionally been applied to improving the reliability of operating nuclear plants or to preparing and depositing wastes into the repositories (La Porte 1978).

The Importance of Scale and Analogical Learning

To understand the social consequences of deploying high benefit/unacceptable damage technologies, we must consider the problems raised by the scale of the enterprise and the need for analogous, less risky phenomena from which to learn. Crucial aspects of scale include the overall size and complexity of energy production and waste-handling systems, the rapidity with which they may be developed, and the extent of the necessary regulatory apparatus.

Our knowledge of these matters is limited to recent experience with large-scale technological organizations. However, discussions of the increasing scale of nuclear power have usually been truncated, attentive primarily to the recent, nearly problem-free experience within that industry. Thus, they ignore what might be learned from other industries that have matured (for example, the petrochemical industry). The discussions also convey the impression that 365 reactor years of experience provide a sufficient basis for extrapolating to the 30,650 reactor years experience that would be gained in the transition to a fully operational nuclear system of 1000 plants (in 2040) were the "national plan" to guide public policy instituted (Rickard and Dahlberg 1978).[5] Does this limited experience provide a sufficiently broad range of knowledge that is easily transferable to a fully deployed nuclear economy?

As the scale of the nuclear economy increases, attempts to establish larger and more reliable operational and regulatory organizations may produce

TABLE 17.2

Contrasting Properties of Demonstration and Full-Deployment Phases of Large-Scale Systems

Demonstration	Full-Deployment
Small scale	Large-scale in size
Simple operations	Complex operations
Experimental, flexible task structure	Routinized, rigid task structure
Informal, one-man coordination	Hierarchical, coalition coordination
Firm sense of executive control	Tenuous sense of executive control
Early warning	Lagged feedback
Error containment, consequences minimized	Error prone, consequences maximizable

novel and unsettling social and administrative demands. This possibility is suggested by the contrasting properties of demonstration and full-deployment phases of large-scale systems noted in Table 17.2. In reviewing this list, it is useful to remember that the industry has emerged from the demonstration phase of nuclear-energy production and until recently has anticipated rapid progress toward full maturity. Some of the problems at TMI seem to be associated with properties of fully deployed systems, especially routinized task structure, hierarchical coordination, and tenuous executive control. The demonstration phase for the disposal of radioactive waste, however, has yet to be completed.

The differences beween the demonstration and full-deployment phases of large-scale technologies suggest that the lessons learned from early experience have only limited application to the fully deployed system. This difference is especially evident when both the operational and regulatory aspects are considered. Thus, any study of the effects of increasing organizational scale within an industry must include the limits of transferring concepts based on early experience to the fully deployed technology.

The magnitude of effort necessary to deal with wastes from the 150 nuclear-power plants expected in the next twenty years is vast.[6] It is estimated that by 2010, some seventeen storage places away from existing or planned reactors (AFRs—away from reactors) would be required as holding places for the wastes that are already stored and those to be produced by reactors presently licensed for construction. Until repositories are opened for the burial of highly radioactive waste, the spent fuel will cool and decay in the storage places. (If no repository could be licensed to accept spent fuel before 2025, thirty-five AFRs would be necessary.) The peak transportation effort in 2010 would be about 40,000 individual truck and rail shipments of spent fuel—from reactors to AFRs and from AFRs to the repositories. Without such an effort, spent fuel would continue to accumulate awkwardly at the reactors, the AFRs, or repositories, thereby compounding the handling and safety problems by crowding the storage spaces.

Equally substantial efforts are required to develop the industrial and regulatory apparatus. Along with continued development in the areas of deployment and regulation of the reactors, the safe management of radioactive wastes represents a significant social commitment. Experience may provide little help in anticipating the public's response to risk and its opinions about nuclear-power or waste-disposal facilities, community reactions to such facilities, the social requirements for public regulation, or the social implications of privately or publicly operated nuclear-power plants or waste-processing systems.

Without direct experience from which to learn, we are forced to rely on experience with large-scale non-nuclear operations that strive for very high reliability; however, close analogies to nationwide nuclear-energy systems are wholly absent and other experience is scanty. The small amount of experience we have derives mainly from small subsections of the military (such as nuclear submarines and Strategic Air Command), the manned-flight space program, and air traffic control; none of these experiences has been systematically reported. One of the principal challenges for new research is to examine the logical requisites and sociological properties of large-scale systems that are the sources of various levels of risks. Close study of existing organizations could give us some indication of the likely consequences of deploying new technologies before we institute them.[7]

Requisites for Nearly Error-Free Organizational Performance: Trials Without Error

When a technology is rich in benefits but must be operated very carefully to avoid incurring unacceptably high costs, strong pressures arise for *trials without error.* In effect, there is a call to attain nearly error-free organizational performance. Given our present understanding of organizational behavior and human-control systems and the social psychology of attentive behavior, at least the following conditions are necessary to design and operate a highly reliable, large-scale organizational system:

1. Unambiguous, nearly complete causal knowledge of how the sociotechnical system functions, which is needed to assure expected outcomes;
2. Nearly errorless performance by both personnel and machines to ensure a consistent level of operation;
3. Error-detecting regimes to identify very small deviations from the oper-

ational norm for each component of the system, including the behavior of the operator necessary to assure reliable functioning (Landau 1973);

4. Redundant "channels" of operation and error-absorbing/rectifying regimes, to continue operations if there are inoperative components or miscalculations by operators and also to repair or eliminate the sources of errors (Landau 1963; Metlay 1978, Chapters 1 and 9).

Three additional conditions are necessary if the technology exists only on a small-scale demonstration phase and if the consequences of error sharply limit the utility of trial-and-error learning:

1. Highly effective systems to contain the consequences of error; thus, if potentially serious errors do occur, the consequences will not affect those outside the organization.
2. A well-developed, tested, and credible science of analogical learning and simulation of large-scale systems.
3. Considerable caution in inferring that what has been learned in the experimental phases will be nearly adequate for the design of highly reliable, ***large-scale*** systems, especially if they are likely to be internally complex and composed of many routine tasks.

These requisites are very rigorous for any kind of technical or organizational system. They are especially stringent when applied to the management of the nuclear-fuel cycle because of the many uncertainties and gaps in our knowledge. For example, we are uncertain of the technical requirements for the design of control rooms that would radically reduce human errors (President's Commission 1979; Lockheed Missiles and Space Company 1976). We are also uncertain about the short- and long-term behavior of wastes in different geological media (NAS 1979a) and know little about the efficient processing of spent fuel into various forms of solid wastes (Rochlin 1979, Chapters 3 and 4). There is almost no knowledge about the scale and dynamics of an integrated nuclear-production and waste-disposal system that takes into account the means necessary to produce highly consistent, nearly error-free performance by the operators and the machines throughout the entire process. Furthermore, although the design of error detecting, absorbing systems, containing systems, and the requirements for redundancies within such systems have been applied to power reactors, they have not been rigorously examined for waste management *in toto*, especially the regulatory imperatives involved.

When improvements in analogical learning are necessary, as they are in this case, it is difficult to put much confidence in our present state of the art or in simulation technology as a substitute for trial-and-error learning (Brewer 1978; NAS 1979a). Experience with widely deployed, integrated systems of nuclear-power production and waste management of substantial scale does not yet exist. Therefore, knowledge about them can only be derived from analogous systems, ones that are similar but not identical. Using this inexact information we could then use simulation techniques, but these have reached only a modest level of complexity and have rarely been tested on very large-scale, complex organizations.

The final requisite reminds us to be wary of applying knowledge about small demonstration projects to the behavior of larger-scale systems. The integrated nuclear-energy production and waste-disposal system envisaged for the United States will be large and complex and will have technical and management activities that invite routinization. In programs that employ sophisticated technologies, the properties of scale, complexity, and routinization increase in direct relationship (Dewar and Hage 1978). As they do, our abilities to devise and operate coordinating processes are severely taxed; the utility of experience based on smaller scale operations is reduced; and the difficulties of coping with analytical and operational demands become acute. The problem can then be posed in terms of organizational reliability and the cost of striving to achieve it: What is the reliability of a system as a function of increasing size, internal complexity, and task routinization? Alternatively, what are the costs of attaining a constant level of reliability and error correction as a function of scale, complexity, and routinization?

For the nuclear-fuel cycle the argument is as follows:

1. In systems that are based on sophisticated knowledge and involve complicated technical processes, increases in the scale of operations require increases in technical and managerial complexity (Taylor 1975). Nuclear-energy production and waste-processing systems fulfill both conditions. They meet the second because of the technical and operational requirements for large reactors, the industrial operations needed to fabricate and transport fuel, and the techniques needed to reprocess waste.

An increased volume of activities requires an expanded work force, which in turn leads to greater differentiation of specialists and technical groups. Differentiation is followed by the spread of formal and informal means of coordinating these specialists and groups—that is, the growth of internal interdependencies (Thompson 1967). As the scale of operations grows, further complexities are introduced to meet the demands of managing and regulating a system of multiple facilities and transport links between them.

2. If the consequences of errors are believed to be very serious, there is a strong emphasis on means for anticipating and/or reducing errors, which further increases formal and informal interdependences by introducing regulatory bodies, inspection activities, safety units, etc. Internal operations and links between facilities will be strongly affected by externally imposed safety standards enforced by agencies that monitor both technological and opera-

tor performance (Linker, Beers, and Lash 1979).

3. The growth of complexity confronts managers with a problematic situation that is difficult to comprehend (La Porte 1975, Chap. 10).

4. The manager's sense of integrated organizational coordination is apt to decline, followed by measures to reduce managerial uncertainty in order to prevent surprises and untoward errors (Thompson 1967). Measures to increase the predictability of operations are likely to include the use of management-information control systems (often involving computerized monitoring procedures) and the standardization of specialized tasks. Elaborate control systems increase reliability insofar as they are based on complete and accurate information about the operation of the system to be controlled (Landau and Stout 1979); however, if the information is incomplete or significantly inaccurate, such control systems tend to encourage a spurious sense of confidence. Routinization reduces costs and usually increases the predictability of performance. Both measures may be effective if the consequences of errors are limited. If they are not, additional efforts are required.

5. The level of worker performance needed to avoid significant error and achieve effective reliability challenges present management practices and design capabilities. Operators must be closely attentive to the demands of the job, however uninteresting the tasks become. More importantly, workers must remain watchful for surprises and be able to adapt to circumstances not usually programmed into their routines. As the size and complexity of operations increase, the adequacy of the knowledge base tends to decline and job programming is necessarily less complete. There is an unrelenting need for reliable and adaptive behavior from workers, even as they are confronted with routinized and automated systems.

This situation challenges management to provide incentives and training to compensate for the error-inducing conditions of routine, familiarity, and continual success. Boredom and familiarity often result in inattentiveness to early signs of error. If there is also continual success—because of error avoidance by both machine and operator—especially during the first several work-generations, the motivation for attentiveness and adaptability erodes because surprise so rarely occurs.[8] Thus the burden on training and incentives is heavy: to motivate able people to remember (through many work-generations) why they should be attentive to a system that seems not to fail and is boringly routine yet demands the instant recognition of the first signs of error and may require self-endangering actions to mitigate the consequences.

Social Science and the Design of Nearly Error-Free Organizational Systems

I have argued that in deploying a complex national system of nuclear-energy production and nuclear-waste disposal, we may substantially increase the likelihood of errors and, hence, the economic and social costs of the system. The successful design, operation, and especially regulation of such a system may not be as straightforward as for other large-scale engineering and regulating systems. The properties of the phenomenon confound established approaches and pose strong technical and managerial challenges.

If the design of large-scale, high-reliability organizations must meet the requirements discussed above, is there an adequate, readily usable store of social science knowledge that could inform such design? That is, can available social science knowledge help us to understand the conditions created by new technological capacities and to modify social relations in accommodating them?

Although there has been some study of the technical aspects of control systems (or "systems safety"), there has been almost no systematic study of the social and/or organizational aspects of such systems, especially those that must remain highly reliable for many work-generations. Management processes, organizational coordination, and measures for error anticipating, detecting and rectifying processes have not been developed. Neither the severity of demands on behavior nor the effects of such demands on personnel or communities are well understood (Hebert et al. 1978; Brenner 1979). In short, we can neither delineate the problems regarding the social aspects of these systems nor provide the detailed knowledge that could lead to their effective design and management, especially because it is necessary to avoid significant error both at the outset and in the development and operational phases.

Improving this situation requires much greater attention to: (1) policy analysis and implementation in areas where incremental, trial-and-error learning has diminished utility, especially in developing techniques of error analysis, detection, and remedy regarding the internal operations of organizations; (2) the social requirements of highly reliable performance in large-scale organizations, paying particular attention to various socialization processes and their fiscal and human costs; and (3) the effects of increased scale and tighter patterns of organizational interdependence on the reliability and costs of the system.

Implicitly, this chapter questions our understanding of the social costs and consequences of dependence on technologies that are rich in benefits but require very reliable operation and management to prevent serious harm. There is a growing number of such technologies, and as the public recognizes their nature we can expect increased demands to reduce their risks by markedly causing their operational reliability to be improved. As we improve our knowledge of the limits of organizational reliability, we may discover that the economic and social costs are very high, particularly as perfection in performance is approached. Even with such efforts, the absolute level of risk reduction may still be unacceptable to many groups in society. If substantial errors do occur, it is likely that the institutions directly involved in the production and regulation of the responsible technologies will be blamed. If there were relatively frequent and significant errors, the legitimacy of those institutions would decline as would confidence in the efficacy of incremental legislative and regulatory-policy processes, which is perhaps the most troubling aspect of the social response to potentially hazardous technologies. This situation highlights yet another area for research: the dynamics of dissent and conditions of consensus in political systems with varied socioeconomic and ideological characteristics as they confront a growing range of low-probability, high-risk technologies.

Notes

1. The length of a nuclear age depends on many factors—e.g., population growth, demand per capita, and development of other energy sources, etc. Including the uranium needed for start-up and losses in the fuel cycle, LMFBRs (liquid metal fast breeder reactors) are estimated to be some 50–100 times more efficient than LWRs (light water reactors). It is thought that breeders could extend uranium supply 10 times, which is viewed as a reasonable heuristic estimate (see Holdren 1979, p. 205ff.; American Physical Society 1978, Chap. 8).

2. Depending on the referent used as a criterion for hazardous levels of radiation (e.g., more than the mill tailings left after the fuel is mined or the level of radiation associated with naturally occurring ore bodies), the hazard time ranges from several hundred years, to 100,000 years, and to longer periods of time (NAS 1976 and 1979b; U.S., DOE 1979).

3. Demands for the immediate deployment of more reactors and solutions to the waste-disposal problems are pressed by those who believe these measures are necessary to avert a severe energy shortage in the near future (*Business Week* 25 December 1978, p. 84; Grahan 1978; Rankin 1978, p. 621; Heimann, 1976, pp. 86–107; and National Economic Research Associates 1979). Others regard these demands as premature because uncertainties about nuclear safeguards exist (Willrich and Taylor 1974; Wohlstetter et al. 1977), the physical properties of stored wastes (NAS 1979a; Johnsson and Steen 1978), and the difficulties of plant operations (President's Commission 1979; Lockheed Missiles and Space Company, 1976).

4. Limited errors within the systems would be (and are) evident, and it is possible to learn from them. The emphasis here is on significant errors that result in breaches of the system and external contamination.

5. There is an extensive analysis of the quantities and character of wastes associated with an intermediate level of deployment to 400 GWe capacity by A.D. 2000 in *Management of Commercially Generated Radioactive Waste* (U.S., DOE 1979).

The estimated reactor-years of U.S. experience, if the national plan were followed to 2040:

Year		*Cumulative Totals*
To 1980 365 from 62 plants		365[a]
To 1990 adding 90 plants to @10 per yr:	$(62)(10) + (9)(10)(11) = 1115$	1479
To 2040 adding 850 plants @17 per yr:	$(150)(50) + (17)\frac{(50)(51)}{2} = 29{,}175$	30,655

[a] Derived from U.S. DOE 1978; and *Nuclear News* 22 1979, p. 71. Based on 62 operating commercial reactors rated *above* 400 MWe (436-1130 MWe). Excludes 7 reactors rated below 400 MWe (50–265 MWe, total 885) as too limited in scale.

6. Recent and tentative logistical analysis of the waste-handling problem suggests that requirements for storage facilities and transportation are higher than previously expected, because of the physical limitations involved in placing spent fuel in storage pools and, when available, in deep geological repositories (MITRE Corp., forthcoming).

7. Some information may be gained from the rapid increase in size and power output of the U.S. air-traffic control system during the past 30 years, and from NASA's manned-flight space program. Information about large-scale dam construction by an industry that puts great importance in designing fail-safe dams is interesting and disquieting, for it demonstrates that even in this very safety-conscious industry there is one dam failure in every 10,000 dam years (Beacher, Pate, De Neufville 1979).

8. This phenomenon seems to have been present in the reactor control room at the Three Mile Island nuclear-power plant. There may also be a good deal to learn from the experiences of guarding ICBMs and managing the Strategic Air Command and the Polaris submarine fleet.

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Part 5

Implications for Public Policy