The Naval Nuclear Propulsion Program: A Brief Case Study in Institutional Constancy

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Institutional constancy is a concept that has been proposed to help explain how, given the close scrutiny that now pertains to such activities, organizations can effectively manage large technical systems that involve hazardous materials with potentially significant long-term consequences. One organization that has effectively managed within such an environment for almost 50 years is the Naval Nuclear Propulsion Program. The program's management methods involve careful organization, meticulous program execution, the achievement of technical excellence, close management of program and contractor personnel assets, and effective communications. The attributes of the Naval Nuclear Propulsion Program compare well to those that have been ascribed to organizations that exhibit institutional constancy. The program demonstrates both trustworthiness and the capacity to enact programs. The program's consistent emphasis on the technical competence of its personnel is a distinctive feature.

The opinions expressed herein are those of the authors. They do not represent the views of either the Naval Nuclear Propulsion Directorate or those of the Defense Nuclear Facilities Safety Board.

In an article published in the November/December 1996 issue of *Public Administration Review,* LaPorte and Keller argued that the management of large organizations that deal with hazardous materials (materials that pose significant risks over long periods) presented "extraordinary challenges for public institutions." They postulated that, in our society, such organizations are "pressed to operate at nearly fault-free levels" in order to remain viable. LaPorte and Keller went on to describe a concept they called "institutional constancy." They argued that such constancy is a necessary (but not sufficient) attribute of organizations, if they wish to achieve public acceptance in their operations with hazardous materials (see also LaPorte and Metlay, 1996).

LaPorte and Keller describe institutional constancy from a number of perspectives: the perceived need for it, the barriers to achieving it, and an outline of the matters that must be attended to if institutional constancy is to be achieved. In suggesting further paths for research, LaPorte and Keller urge that case studies be developed that examine "the characteristics and experiences of institutions" that have achieved a degree of institutional constancy. They mention a number of organizations that, based on externally available information, appear to meet their criteria for institutional constancy. One of these organizations is the Naval Nuclear Propulsion Program.

The authors concur that much can be learned regarding institutional constancy by reviewing the history, organization, and management of such organizations as the Naval Nuclear Propulsion Program (or Naval Reactors, as it is more commonly known). This program is responsible for the design, construction, operation, maintenance, and decommissioning of the nuclear power plants that propel approximately 40 percent of the major combatant ships of the U.S. Navy. As such, Naval Reactors has managed the building and operation of approximately 240 nuclear reactors and, importantly in today's environment, safely and responsibly decommissioned more than 50 of these reactors and their associated equipment. Since the organization has safely and effectively dealt with the hazards associated with nuclear power for almost 50 years, it seems appropriate to evaluate some of the reasons for that success.

In the following discussion, Naval Reactors will first be described from an insider's perspective, that is, discussed in terms that the program (and its chroniclers) have employed. This description is intended to provide a "feel" for the program. The attributes that emerge during this discussion will then be compared to the basic structure of institutional constancy described by LaPorte and Keller.

Inside Naval Reactors

Naval Reactors is a joint program of the Navy and the Department of Energy. The need for a joint effort stems from the fact that the Department of Energy is the only government agency empowered by law to conduct research and development on power reactors (Rockwell, 1992, 44-46, 54-64; Duncan and Hewlett, 1974, 60-67, 88-94). In basic terms, the Navy defines the required features of the nuclear power plants; the Department of Energy develops and tests the plants to ensure that they meet the requirements. The Navy builds, operates, and decommissions the shipboard plants, and then turns the decommissioned reactor plants over to other organizations within the Department of Energy for burial.[1]

Very early in the development of naval nuclear power, H. G. Rickover, then a Navy captain, saw that this statutory division of responsibilities posed grave difficulties. He recognized that the development and utilization of this revolutionary new source of power should be treated as a series of closely related technical functions including research and development, detailed design, procurement of apparatus, maintenance and repair of equipment, and selection and training of personnel. With these considerations in mind, Rickover moved boldly and with remarkable political astuteness to arrange that a single organization be assigned the key responsibilities of *both* the Navy and the Atomic Energy Commission (the Department of Energy's predecessor).

There were imposing barriers to such an arrangement. Rickover had to overcome inertia and active resistance within both the Atomic Energy Commission and the Navy. For example, the Atomic Energy Commission was preoccupied with the development and manufacture of nuclear weapons; however, for its early research and development, Naval Reactors had to rely on the national laboratories of the Atomic Energy Commission. The Navy, for its part, would have preferred to fit the nuclear submarine program into its well-established organizational structures and methods of designing and constructing ships, rather than experiment with this radical joint organization with the Atomic Energy Commission (Rockwell, 1992).

Rickover overcame these impediments, and more, by working at the top of both organizations. He first garnered the support of the Chief of Naval Operations for the concept of a nuclear-powered submarine and elicited a memo from him directing the Navy's ship design agency to undertake such an effort jointly with the Atomic Energy Commission. Rickover then inveigled the Bureau of Ships to assign him the responsibility of negotiating an agreement with the Atomic Energy Commission. When the dust settled, Rickover was the only person with feet solidly planted in both camps, and he was named director of the program (Duncan and Hewlett, 1974, 88-92). As a top priority, he set about quickly to establish a strong and enduring relationship with Congress, specifically the Joint Committee on Atomic Energy, which had comprehensive oversight of all nuclear matters during that era. It was, however, a consistent string of design and operational successes that solidified Naval Reactors' relationship with Congress. It is a relationship that served the program well and endures to this day.

In parallel with these political maneuverings, Rickover worked to impart his vision and inculcate his principles and standards of excellence in every facet of Naval Reactors. He did so in a way that ensured success during his own tenure as director of the program (from its inception through 1982), and in a way that laid the foundation for enduring success. To appreciate the magnitude of this technical undertaking and the managerial tour de force that it involved, one needs to understand where Rickover began. When he started, no reactor designed for useful amounts of power production had ever been built. Yet he undertook to build one immediately for the extraordinarily difficult application of submarine propulsion. It was an immensely inspiring vision, one that both motivated his organization and ensured success in selling its program. In achieving success, he and his organization scored an engineering accomplishment of historic magnitude.

To understand how Rickover accomplished all of this requires that one become acquainted with his principles and methods of organization, program execution, the achievement of technical excellence, the management of personnel and other resources, and the ensuring of effective communications. These were the ingredients of his success; they offer valuable lessons for other hazardous, technically complex programs that wish to have enduring success.[2]

Organization

The Naval Reactors organization embodies a number of basic principles of sound management, which are all too often "more honor'd in the breach than in the observance." The unique strength of Naval Reactors has been that these principles are applied throughout the program logically and consistently with unremitting rigor.

A principle of transcending importance is that every organizational unit and each individual has responsibilities that are defined clearly and understood thoroughly. Careful attention is given to seeing that these responsibilities are internalized, that the name of an individual is identified unambiguously with each required function, and that these responsibilities are put in writing. Naval Reactors policy and practice gives emphasis to this principle to a degree matched by few organizations.

Assigning responsibilities with this stark clarity presupposes that there exists a clear definition of the respective responsibilities for the organizations involved, notably the government and its contractors. The cardinal principle applied by Naval Reactors is that the government itself is the customer—and an exacting one at that—for each and every activity and function that contractors are engaged to perform. The contractor is required to meet the requirements of the contract in all respects. Naval Reactors built up an outstanding technical staff (discussed further below) to ensure that it could perform as a "demanding customer." However, it is clear Naval Reactors policy that the competence of the Naval Reactors staff is not to be used to compensate for weaknesses in the capabilities of the contractor; but rather to cause them to be corrected. Few policies are more central to the success of the program than maintaining this clear distinction between the roles of the government and the contractors.

As noted earlier, a single unified organization was established to carry out the respective responsibilities of the Atomic Energy Commission and the Navy. This unified aspect was strengthened as the

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program grew and the organization was extended nationwide. The heads of each field activity in the Naval Reactors program reported to the director rather than to some key assistant. This arrangement produces a very flat organization; at times more than 20 people report directly to the director. In such an organization communications are very important (as discussed below). The mode of operation is highly unified, yet flexible; new groups are formed and old ones disbanded based on the demands of the work. Ultimate authority and responsibility resides with the director, who delegates appropriate authority to headquarters and field personnel. Field personnel truly function as a part of the headquarters organization, simply displaced by geography.[3]

This close-knit style of organization enhances program unity and helps ensure uniform application of policies, standards, and practices. Unity is also fostered by the practice of staffing senior field positions from among those who have demonstrated effectiveness at headquarters. Finally, this unified organizational structure helps to suppress factions and avoid the tensions and conflicts between headquarters and field organizations that all too often hamper the progress of large, technically-complex, hazardous endeavors.

Program Execution

A salient feature of program execution at Naval Reactors is the willingness to face facts squarely and objectively, especially those concerning technical matters. Central to this approach is the Rickover philosophy that "technology had imperatives of its own," based on immutable laws of nature, to which deference must always be paid. These laws can not be challenged with impunity; yet all too often, otherwise capable managers, whether from lack of technical knowledge, contractual incentives, or personal ambition, imagine that they can do so (Duncan, 1990). With his many years of engineering and program management experience, Rickover was especially vigilant to detect and counter these tendencies. His effective transmission of this experience to the Naval Reactors organization has been a major factor in its success. For example, at a perilously late stage in the development of the program's first reactor (the prototype for the first nuclear submarine, *Nautilus*) Rickover made the contractor scrap a fatally flawed design for a vital safety system and instead manufacture a totally new, simpler design.[4] His courage to face technical reality and take forceful action helped foster an organizational commitment to confront technical reality in all its details early and head on whatever the consequences. This became a characteristic mode of operation at Naval Reactors and it works to avoid potential failure to meet agreed-upon program objectives, especially in safety and quality.

Significant attention is always given to assigning work consistent with priorities. For example, at a crucial stage in the program, during a burgeoning nuclear shipbuilding program, one of the corporations involved decided to do a study for a new design of a reactor plant for destroyers. Over Rickover's objections, the firm was awarded a large contract to study its radical design concept. Two years later, the firm issued a report urging that a major program be undertaken. To avoid having resources diverted from building up the nuclear fleet, Rickover dedicated a team of his top engineers to develop a report for the Atomic Energy Commission that technically demolished the proposed reactor design. The destroyer reactor project based on the discredited technology was never advanced again. The engineers at Naval Reactors who were involved complained that they had been diverted from higher priority work to scotch this effort; Rickover convinced them that a high visibility failure (as this concept would have proven to be) would have had adverse impacts on the industry in general, and on naval nuclear power in particular. Rickover always awarded high priority to protecting the program. It remains a high program priority today (Duncan and Hewlett, 1974, 276-278; Schmitt, 1992).

Another distinguishing feature of Naval Reactors is that operations are conducted with a high degree of formality and are rigorously documented. All work is conducted with a disciplined engineering approach, making full use of available program and consensus standards. The all too common "laissez faire" approach, in which an individual or organization, however well-qualified, is allowed to conduct work without due attention to sound engineering principles and independent checks, is simply not tolerated. This disciplined, formal engineering approach is pervasive in every phase of activities at Naval Reactors: development of codes and standards where none exist, the availability of formalized design manuals and engineered test procedures, the detailed analysis of proposed designs, and the rigorous application of quality assurance, to name a few. Some individuals may find this rigor irksome when they first encounter it. However, over the years, a comprehensive set of standards and procedures has been developed that has contributed importantly to the safety and reliability of the reactor plants that Naval Reactors builds. This set of standards and procedures permits innovation to be applied in a controlled manner and allows focus to be placed on truly important areas, while ensuring that routine work gets done competently.

Program execution is strongly marked by the application of the principle of redundancy. The objective is never to be dependent on a single source of anything: information, supply of material and equipment, design approaches, assessment of quality, or personnel. The list could extend indefinitely. Application of this principle can be seen in the early establishment of two reactor plant engineering laboratories. The strong, competitive capabilities of these two laboratories have been an important source of strength for the Naval Reactors program, and the laboratories are often used cooperatively to address technical problems of common program interest.

Achieving Technical Excellence

Achieving technical excellence in design and execution is perhaps the supreme objective that informs and drives all Naval Reactors activities. All policies, practices, and procedures are directed toward achieving this objective (Rickover, 1979b). Achieving it requires that personnel acquire the disposition—as a way of life—to examine matters in detail with an attitude of objectivity concerning assumptions, validity of data, and the like, coupled with an imaginative conjecture of how things could possibly conspire to go wrong. Development of this disposition complements the disposition mentioned earlier of giving due regard to the laws of nature. It is tested most when careful analysis discloses flaws that might compromise excellence and therefore require adopting new approaches, even though such a change may sometimes threaten cost and schedules.

Another key way of achieving excellence is through effective use of consensus engineering codes and standards. In principle, this is not unusual. What was unusual in the early days of Naval Reactors was the technical thoroughness and managerial force with which the program applied the principle. Since there were few standards specific to the newly born nuclear power industry, Naval Reactors examined and upgraded applicable standards from conventional power plant practice and submarine design. Where no standards were available or suitable for use, Naval Reactors developed its own standards and continually upgraded them as the program accumulated experience.

Yet another obstacle had to be overcome in the early days of the program—unsound notions of the role of research and development in mission-oriented endeavors. The Naval Reactors view was that research and development work funded by the program had to contribute directly to program objectives. A different view, encountered frequently at the time in the national laboratories of the Atomic Energy Commission, was that scientists and engineers ought to be funded on the basis of competence and be allowed substantial latitude in the choice of problems to be addressed and methods used. Such an attitude did not support the high national priority Rickover perceived for the nuclear submarine project. In addition the anticipated need for substantial industrial experience for the actual shipbuilding programs caused Naval Reactors to establish its own laboratory structure dedicated to naval reactor applications, run by industrial giants (Westinghouse and General Electric), and operated under close Naval Reactors supervision and guidance.

The technical excellence sought in the Naval Reactors program is embodied in the high quality, reliability, and safety of the components, systems, and plants that it produces. In achieving this result, Naval Reactors makes wide use of quality assurance, but it does so in a manner that preserves to line management the final responsibility for quality. It emphatically does not tolerate the aberrant and harmful interpretation that "the quality department is responsible for quality"; its proper responsibility is to *confirm* that quality is achieved.

Asset Management

Naval Reactors views its personnel, both government and contractor, as its primary asset. Obviously, all program personnel must be fully competent, especially concerning technical qualifications. Naval Reactors must have the competence, in all areas, to provide effective technical direction and guidance. Selection and training of Naval Reactors personnel is thus accorded the highest priority among all program endeavors. Similarly, Naval Reactors continually evaluates the technical competence of its contractors to ensure that it is sufficient to a very demanding task.

To meet its own needs for personnel Naval Reactors has drawn on many existing sources and developed others tailored to its needs. Initially, large numbers were drawn from among naval officers with advanced technical education who had specialized in engineering. As this source dwindled, cadres of gifted graduates of the Naval Reserve Officer Training Corps (NROTC) at colleges and universities were selected and given advanced engineering education at the Bettis Reactor Engineering School, established by Naval Reactors at the Bettis Atomic Power Laboratory. As needs continued to mount, additional programs were developed to harvest talent available from other sources such as other college graduates and graduates of other Navy programs. It came to be recognized that the essential approach was to cast a wide net to attract individuals of outstanding technical and managerial capability early on and then educate and train them further in the task of working on nuclear power. It has been a highly successful approach, and indeed, is considered one of the hallmarks of the Naval Reactors program.

After suitable candidates are identified, utmost attention is given to the selection process. Each candidate is interviewed by at least three senior technical managers, personnel whose judgement is trusted by the director. The attributes sought include: technical ability, mental alertness, industry, imagination, dedication, moral integrity, and growth potential. In trying to gauge technical ability, the interviewers attempt to "get behind the grades" to understand the candidates' ability to apply the material they have learned in a logical, coherent fashion. The capstone of the process is an interview with the director, who, provided with the results of previous interviews, makes the final determination.

These two approaches, casting a wide net to garner the best qualified candidates, and a rigorous, comprehensive interview process, ensure a steady stream of well-qualified personnel into the nuclear fleet and Naval Reactors' technical staff. Regular, detailed reviews of long-term performance ensure that only top performers move into positions of responsibility. In the fleet, major "checkpoints" occur when mid-career officers cycle back through Naval Reactors headquarters to qualify as engineering department heads. Senior officers run the qualification gauntlet again prior to achieving command of a nuclear ship. At Naval Reactors headquarters, young engineers are rigorously reviewed prior to being granted "signature authority" (authorizing them to sign contractually binding correspondence for the director). They are reviewed again when their initial four to five year tour at Naval Reactors is complete, at which point the program determines whether or not to offer them a permanent job.

This approach to meeting personnel needs—wide recruitment, rigorous screening, and regular, comprehensive reviews—is not unique to Naval Reactors; in fact, other institutions of long standing, such as the U. S. Marine Corps and a number of religious orders, focus similarly on "growing their own" talent. Institutions that endure share with Naval Reactors the attribute of consistent attention to the development of their personnel. This attribute enables them to adapt to an ever-changing environment (Duncan, 1989, 238-251; Rockwell, 1992, 229-230, 293-295).

Acquisition of the Naval Reactors customer capability is the sine qua non of achieving the needed level of contractor capability. The two phenomena may seem unrelated at first; however, it is Naval Reactors' experience that contractor performance will only be as capable as a capable customer makes it be. The contractor is often obliged to distribute top technical talent, always in short supply, among many projects and programs. The consistently demanding customer is the one most likely to have the needs of its program met. Few can match Naval Reactors in this category.

When a contractor has been able to acquire the strong capability needed to perform well, often with considerable difficulty, it is tempted to reassign these newly found strong performers to other corporate needs. Naval Reactors has always exercised consistent vigilance to assure that its programs are not misused in this manner.

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Generally, Naval Reactors uses its contractual vehicles, in concert with other less formal mechanisms, as strong incentives against such corporate actions, but these incentives do not develop automatically.

Communications

The final component to the Naval Reactors structure—the one which ties the program together—is communications. The communication system is based on effective and thorough internal communication, which lays a solid foundation for building communication links to outside groups.

Keeping up with what is going on in nationwide programs such as Naval Reactors has always been daunting. The comprehensive approach taken is characteristic of the program. Each top manager in the field, both government and contractor, is required to write the director of the program a weekly report (headquarters personnel are clearly at the call of the director whenever reports are required). This report is expected to be concise, but care is taken to describe each problem adequately, to assign a responsible individual, and to provide a schedule for updates and resolution. For fast-breaking issues these reports are often followed up with phone calls to the director. Due to the broad responsibilities assigned personnel in the program, the director often receives reports of the same problem from several perspectives; this ensures that Naval Reactors receives complementary, independent reports on vital issues.

Communications do not just move up the chain of command. In keeping with Naval Reactor's commitment to formality, all actions taken by headquarters are promptly documented and communicated to all activities involved. This provides the basis for an ongoing dialogue between Naval Reactors headquarters, its field offices, and its contractors. Communications in writing, coupled with the formal proposals required by Naval Reactors of its contractors, provide a clear written record of the actions and decisions of the program. This permits effective interfacing with outside groups, whether they are auditors (e.g., the General Accounting Office) or they provide oversight (e.g., the Advisory Committee on Reactor Safeguards, an arm of the Nuclear Regulatory Commission and even more notably, Congress).

Naval Reactors provides an annual review of its operations to Congress along with its budget submittal. This review goes into great depth regarding the health and safety record of the program; a summary version of this report (known as the *Grey Book*) is also updated annually. These comprehensive reports, coupled with regular, effective congressional testimony, are very valuable in marshaling support for Naval Reactors' programs.

Naval Reactors and Institutional Constancy

LaPorte and Keller (1996) postulate two major avenues by which organizations build institutional constancy. First, they demonstrate that they are worthy of trust, and second, they develop and demonstrate the capacity to execute the programs entrusted to them. The following sections will describe how the attributes of the Naval Reactors program contribute to achieving these two ends.

Demonstrating Trustworthiness

The attributes that LaPorte and Keller delineate under this category include: (1) the development and implementation of formal written goals, (2) the strong articulation of a commitment to constancy, (3) the fostering of strong institutional norms and processes, and (4) the presence of vigorous external enforcement or oversight.

Formal, written goals have been the backbone of the Naval Reactors program since its inception. A formal, written goal (the commitment to produce a nuclear reactor for submarine propulsion) launched the program in the late 1940s. Prior to that no firm foothold could be found for the program. From that basic goal a number of subsidiary goals were derived that further defined the design requirements of the submarine propulsion plant. Other written goals followed, many having to do with public health and safety, such as a goal of "no significant discharges of radioactivity to the environment," and other similar technical challenges.[5]

The Naval Reactors program embodies its commitment to constancy in a philosophy of operations. Since its very early stages the program has espoused a "cradle to grave responsibility" for the nuclear power plants that it designs and builds. In effect, such a philosophy operationalizes constancy, which is put to work in concepts such as responsibility, as well as in the clear definition of roles, and the need for technical excellence in all aspects of the program.[6]

Even very visible advertisement of the goals and objectives of the program is not enough, however, as LaPorte and Keller point out. These goals and objectives must be supported by institutional norms and formal internal processes. Naval Reactors ensures that its goals and objectives are put into practice through a number of program attributes. First, the program inculcates the norm of personal responsibility; each member of the program is personally responsible for the work he or she performs. Second, the program ensures that the cutting edge of program management, the field element managers, have first been successful in headquarters assignments. Their track records make it possible for headquarters to delegate wide latitude to them once they are in the field. A third institutional norm or set of norms concerns the manner in which the technical work of the program is performed. Such norms include attention to detail, adherence to consensus and program standards, and a dedication to technical inquisitiveness and appropriate research and development. These program norms and processes help to ensure that program objectives are met.

Naval Reactors was born in an age where there was less focus than today on external regulation. However, from the very early days the program recognized the value that could be provided by external review of its design and practices. Under the aegis first of the Atomic Energy Commission and subsequently the Department of Energy, the reactor plant designs for each class of ships are reviewed by the Advisory Committee on Reactor Safeguards. Comments received from the committee, although not mandatory for the program, are treated seriously and are resolved prior to design acceptance. In the early years of the program close congressional scrutiny was provided by the Joint Committee on Atomic Energy. This powerful committee was responsible for all nuclear matters until the early 1970s and it provided detailed oversight of the program. The

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format and content of Naval Reactor's testimony to Congress was developed in those early days of detailed scrutiny and endures to this day. Thus, significant external oversight of nuclear safety in the program exists, although it is not as formal as it is in some programs.

In addition, since the mid-1980s, Naval Reactors has opened its program to external oversight of environmental matters. Naval Reactors has dedicated a separate division to deal with environmental protection and compliance matters. This division, working closely with Naval Reactors' contractors, ensures that environmental problems are rapidly identified and corrected. This rapid response has led to good working relationships between Naval Reactors and state and federal regulators in this arena.

Agency Capacity to Enact Programs

In describing the conditions necessary to ensure that agencies have the capacity to enact their programs, LaPorte and Keller cite three major attributes. These attributes are: (1) adequate administrative and technical capability to assure performance, (2) analytical supports that incorporate the interests of the future, and (3) effective capacity to detect and remedy failures early on. How the Naval Reactors program achieves each of these attributes is discussed below.

A critical foundation for the program's infrastructure is its ability to establish, define, and protect a domain that encompasses its responsibilities totally. This was never easy to do. From the outset of the Naval Reactors program, the Atomic Energy Commission (now the Department of Energy), the Navy, and other organizations made repeated attempts to curtail or modify those responsibilities. Naval Reactor's policy has been to defend its domain vigilantly against such intrusions. Its effective protection of its prerogatives gives it the freedom to meet its programmatic goals and responsibilities and prevents its energy from being sapped on unnecessary squabbles.

Naval Reactor's ability to define and maintain the boundaries of its program is best illustrated in its establishment and maintenance of control of the selection, education, and training of program personnel. Personnel has always been an issue of major importance to the Navy. Rickover and later directors have insisted that they be the final arbiter of an officer's acceptability for technical or operational duty, and that the decision be based (in key part) on a personal interview with the director. The Navy blanched at placing such authority with a single individual; however, Naval Reactors sustained its position based on the issue of nuclear safety and the personal responsibility for safety that the Director has demonstrated (Duncan, 1989, 245-249; Rockwell, 1992, 235-244).

Naval Reactor's ability to enact its programs is further enhanced by its unity as an organization. This unity renders it relatively immune to the conflicts that have beset other programs, especially the tensions between headquarters and field organizations. Naval Reactors managers are imbued with the feeling of being part of a unified organization, one with clear management policies and practices and well-articulated goals. This organizational cohesion is not stultifying; all are encouraged to recommend improvements, both organizational and technical, confident that optimal solutions will emerge from such ongoing dialogues.

Few aspects of Naval Reactors activities are more essential to enacting programs effectively, especially programs associated with hazardous materials, than the formal measures used to execute them. These measures, which apply to each stage of the program from design through decommissioning, have been developed to meet specific needs and are progressively strengthened, incorporating experience as the program progresses. As with other Naval Reactors management methods, the use of disciplined formal methods is not new; however, the thoroughness and discipline with which the concept is applied throughout the program is rarely found elsewhere.

Important as the development of formal systems is, the success of such systems depends on their discerning use by contractor and Naval Reactors personnel. Thus, selection of such personnel is accorded the highest priority among all activities. The policy is to pick the brightest, best educated, and most accomplished, and then to give them the best nuclear education and training that can be found or developed within the program. Attention is then paid to personnel development, ensuring that staff members receive assignments of progressively increasing responsibility and also that the more pedestrian performers are screened out.[7] It is in the strength of its personnel, at all levels, that Naval Reactors differs most from other government organizations.

The strength of Naval Reactor's personnel supports another fundamental premise of the program: that Naval Reactors has technical and managerial capability at least equal to that of its contractors. Otherwise, Naval Reactors could not reasonably expect to provide contractors with meaningful technical and programmatic direction or act as a demanding customer in reviewing products delivered. Because of the safety implications of the work performed, contractor personnel have to be among the very best. Another distinguishing feature of Naval Reactors is the depth to which it manages its contractor. Naval Reactors considers the acquisition and maintenance of technical competence on the part of contractors a contractual obligation. It has established adequate contractual structures and, more importantly, strong, enduring relationships with its contractors to ensure that contractual obligations are met.[8]

A principle paradigm of the Naval Reactors program, one that contributes to the program's "future focus," has been the aforementioned "cradle to grave" responsibility that it maintains for the nuclear power plants under its purview. This understanding of the long-term responsibility associated with using radioactive materials, coupled with the program's commitment to clearly delineated and documented roles and responsibilities, has provided the necessary emphasis on responsible, forward-looking technical decision making. It has also led to outstanding performance in the areas of environment, safety, and health, as documented by recent independent assessments.[9]

The extensive internal communication system that Naval Reactors has in place also ensures that it is very responsive to problems as they arise. In addition to the management reports discussed above, several special reporting systems exist to document quality problems and unusual occurrences as well as to record changes required in the formal system of manuals and procedures that establish program requirements. All of these systems require formal, technical resolution of the problems identified and appropriate, authoritative approval of problem resolutions.

Challenges to the System

The systems put in place by Naval Reactors worked well the vast majority of the time. However, that does not mean that the perturbations to these systems did not happen—they did. Naval Reactors' responses to three systematic challenges are described below in an effort to further explicate important aspects of the Naval Reactors program.

Naval Reactors' attention to personnel matters does not mean that no "turkeys" ever slip through. In fact, roughly 10 percent of those brought in for training fail, mostly for academic reasons—this is one of the functions of the rigorous, phased training program that Naval Reactors uses. However, each problem case is handled individually, and the causes are thoroughly researched. Often, extensive remediation efforts are attempted, and no naval officer (or for that matter, civilian engineer) is dropped from the program without the personal, written approval of the director (Duncan, 1990, 248).

Perhaps at no time are programs and their systems tested more severely than during disasters; Naval Reactors went through one such searching period when the nuclear submarine *Thresher* was lost at sea in 1963. Towards the end of the Navy's investigation of that tragedy, a senior naval officer questioned whether the rigorous, detailed procedures that were used to operate the reactor might not have impeded the doomed ship's ability to re-establish propulsion as the submarine sank. Rickover reacted to this stimulus immediately and characteristically. He responded on two fronts. First, he had his engineers review the existing Navy technical analysis of the incident. They detected significant discrepancies and were able to exonerate the reactor from potential blame. However, Naval Reactors did not stop there, it accelerated an already existing program to simplify reactor startup procedures. By the time Rickover was asked to respond to the Joint Committee on Atomic Energy, he was armed with revised technical analyses and a forward-looking corrective action program.[10]

The ultimate test of the system Rickover built came in 1982, when "The Admiral" was involuntarily retired for "actuarial reasons"—he had just turned 82 (Duncan, 1990, 291). How would the program change? The answer? Very little. Given the difficulty that most organizations go through in making the transition from a charismatic leader such as Rickover, how was it accomplished? The answer to this question harkens back to one of the fundamental tenets of the Naval Reactors program—formality. The well-established standards that existed pertaining to the design, construction, operation, maintenance, and decommissioning of reactors remained in effect and continued to guide the technical work of the program. Also, agreements were reached between the program (supported by its allies in Congress) and the White House to codify the management arrangements between Naval Reactors and the Navy and the Department of Energy. By and large, Rickover's personal boundary management efforts had maintained these arrangements previously. Now they were based on Executive Order 12344 (which was later superseded by statute).[11]

Conclusion

We believe that the Naval Reactors program comports well with the programmatic attributes that LaPorte and Keller deem necessary for institutional constancy. Review of the program's response to several systematic challenges provides additional support to this conclusion. It is clear that some attributes are addressed more strongly than others, as will be discussed briefly below.

> "The *Admiral" was involuntarily retired for "actuarial reasons" How would the program change? Very little.*

In the area of demonstrating trustworthiness, Naval Reactors places particular emphasis on formal, written goals and a strong articulation of those goals. One of these goals, cradle to grave responsibility for its nuclear power plants, also helps produce the necessary commitment to constancy. Due to the program's outstanding safety record, it has yet to be subjected to formal external oversight or regulation of nuclear safety; however, it does submit its reactor plant designs to the Advisory Committee on Reactor Safeguards for review and is subject to regulation in environmental matters.

Naval Reactors has placed its major emphasis in the area of developing agency capacity to perform. Primary program focus is applied to developing and maintaining the capability to execute programmatic goals. The major source of such capability is the truly outstanding men and women, both government and contractor, who have been attracted to the program. It is their acumen and commitment that makes the error detection capability of the program so responsive and ensures that the program is always looking to the future.

It is the view of the authors that the importance placed on the selection, education, and training of personnel, and their subsequent retention in an organization, is of preeminent importance to government organizations trying to exhibit institutional constancy. By carefully screening its personnel, developing their capabilities, and ensuring that they continue to have meaningful work, Naval Reactors has performed well in this area, to date. This capability has been aided by the program's relative autonomy, which has been aggressively defended. Such autonomy permits constancy of purpose (George, 1995). It is in their personnel that government organizations develop their capacity to excel and achieve enduring success.

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Notes

1. This breakdown of responsibilities is notional, since Naval Reactors is truly a joint organization; however, this discussion follows along the lines of the program's budget, testimony to Congress, and discussion in *The Grey Book* (Naval Reactors, 1996).
2. This discussion of the principles and methods described herein is drawn from a number of sources. Principle reference was made to the definitive description of the program provided by Admiral Rickover to Congress in 1979 in the wake of the Three Mile Island nuclear reactor accident (Rickover, 1979b, and U. S. Congress,1979). Reference was also made to a rare article written on the subject of management by Rickover late in his career (Rickover, 1979a), private discussions between two former Deputy Directors of the Naval Reactors Program and, of course, the authors' combined 20 years of experience in the program.
3. The flexibility and responsiveness of the Naval Reactors organization is discussed further by Lewis (1980, 89-91). For example, he notes that Naval Reactors made "rapid internal structural shifts in response to the twists and turns ... of the new technology."
4. The safety system in question was the drive mechanism for the reactor control rods, a system used to control the rate at which the reactor was brought to power and to safely shut it down. Naval Reactors was concerned that the system, composed as it was of several mechanical components that were of a highly developmental nature, would not perform reliably once installed. Rickover had one of his engineers and a laboratory engineer individually evaluate each component and report their findings. This report confirmed the decision to scrap the highly experimental design and go into redesign. One of the authors of this article (Crawford) was the Naval Reactors engineer involved; when the second author came to Naval Reactors 25 years later, this example was still in use. Further details are provided in Duncan and Hewlett (1974, 145-148).
5. These goals played an important part in congressional testimony; updating progress in reaching these goals, in great detail, became a regular feature of the program's written statement. Naval Reactor's success was well documented in a comprehensive review of environment, safety and health performance performed by the General Accounting Office in 1991. See U. S. General Accounting Office, 1991.
6. Program philosophies undergo their greatest tests during times of intense scrutiny; correspondingly, the best overall statements of the goals and objectives of the Naval Reactors program came in the wake of the sinking of the nuclear submarine *Thresher* and in the aftermath of the Three Mile Island nuclear accident. Reference should be made to the congressional testimony provided by Admiral Rickover during these time periods (U. S. Congress, 1965; U. S. House, 1979).
7. The Naval Reactors program has a unique advantage in screening personnel. The vast majority of technical staff are brought in as military officers for a four or five year tour. This provides, in effect, an extended probationary period, allowing full evaluation of a candidate's qualifications for long-term program contribution. Top performers are offered civilian employment after their initial military tour is over.
8. For example, Westinghouse has run the Bettis Atomic Power Laboratory in West Mifflin, Pennsylvania, since its founding in the early 1950s. Electric Boat in Groton, Connecticut, built the first nuclear submarine, *Nautilus*, and is still building submarines for the Navy today. Lewis (1980, 35-37 and 91-92) notes that Rickover brought a respect for the ability of industry to solve problems with him to Naval Reactors from his days at the Electrical Section of the Bureau of Ships during World War II. Naval Reactor's management philosophy reflects a thorough understanding of industry's strengths and weaknesses.
9. Here we refer to year-long review by the General Accounting Office (GAO) performed between January 1990 and February 1991. At the conclusion of this comprehensive review of environmental, health, and safety practices of the Naval Reactors program, *GAO made no recommendations.* Such a situation is almost without precedent. In summary GAO stated: "The programs and procedures implemented by the laboratories and prototype training sites are adequate to protect workers and the environment from radioactivity and hazardous materials" (GAO, 1991, 2). This is a simple statement, but one that speaks volumes. Over and above this summary statement, GAO noted particular strengths in the areas of radiological controls and nuclear safety. Separately, the government of New Zealand performed a review of the safety record of Naval Reactors that came to similar favorable conclusions (Special Committee on Nuclear Propulsion, 1992).
10. In addition to Rickover's congressional testimony (U. S. Congress, 1965), significant detail is provided on Naval Reactor's reaction to the loss of *Thresher* in Duncan (1990, 52-98, especially, 89-93).
11. The codification referred to occurs in Public Law 98-525, Naval Nuclear Propulsion Program. Further details regarding this transition period in the Naval Reactors program can be found in Duncan (1990, 291-292) and Rockwell (1992, 362-362). However, the transition was probably best summarized by Rickover's successor, Admiral K. R. McKee in his initial testimony in front of Congress: "There will be no reductions in standards, or changes in the proven practices that have been instrumental in achieving the level of competence and technical integrity we currently enjoy in every aspect of the program."

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