

THE MIT INTERNATIONAL PROGRAM FOR ENHANCED  
NUCLEAR POWER PLANT SAFETY

Organization and Management in the Nuclear  
Power Industry

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WP# BPS 3435-92

May 1992

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**Report of the Panel Meeting  
Nuclear Power Industry Executives Advisory Panel  
MIT Sloan School of Management  
Cambridge, Massachusetts  
April 22-23, 1992**

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## EXECUTIVE SUMMARY

The Nuclear Power Industry Executives Advisory Panel provides channels of communication between the Organization and Management Study Group of the MIT International Program for Enhanced Nuclear Power Plant Safety and top managers actively concerned with important strategic and operational issues relevant to safety. The Panel is conceived as an opportunity for utilities to share their knowledge and concerns about aspects of management and organization, both within plants and in the institutional context of the national and international nuclear power industry. Further, the Panel seeks to identify opportunities for collaborative research with practical benefits.

At the first Panel meeting, 16 representatives from nuclear power plants and utilities in four countries and 11 MIT faculty, research staff, and students explored mutual interests and priorities in order to guide future research efforts. Roundtable groups selected four topics for discussion: compliance and autonomy; cost control and safety; plant aging and workforce changes; and cross-functional complexity. Edward A. Brown, former CEO of New Hampshire Yankee, provided an insider's perspective on the Seabrook construction project.

The MIT researchers discussed their proposed research design featuring three interrelated studies conducted in utilities that operate multiple plants, one at each utility a self-identified good performer, and a second needing improvement. Dr. Constance Perin discussed a study of how outage planning and implementation utilizes organizational pathways "off the organizational chart" that bridge across functions, levels, and technical groups; Professor Alfred Marcus proposed case studies of performance improvement as a problem-solving process in which plants draw upon an inventory of organizational solutions that affect problem symptoms and core activities; Professor John Carroll focused on ways to characterize the organizational knowledge distributed among various professional groups in the plant, and its relationship to performance enhancement. In addition, Professor Donald Schon discussed possible modes of collaborative research in which the Study Group participates in plant enhancement programs. Such research could satisfy both scientific and operating goals, and build bridges between academic and practitioner approaches.

The wide-ranging discussion explored topics of mutual interest, including a variety of research opportunities and resource constraints. The Panel expressed a desire to be more directly involved in the Study Group research by having more detail about theories, more access to data, and opportunities to contribute interpretations of research observations. The Study Group will work toward appropriate "case-like" materials. There was considerable support for more intensive collaborative modes of research, and recognition of the considerable resource commitment they entail. The Panel suggested efforts to examine the organization and management of the regulators and their impact on plant performance. Next steps were detailed for continued communication between the Panel and the MIT Study Group.

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## Background

The Organization and Management Study Group is conducting a long-term research project whose goal is to develop conceptual frameworks relevant to the management and organization of nuclear power plants, and self-design tools that can help plants meet demands to balance safety, efficient production of electricity, and profitability. This project is part of the MIT International Program for Enhanced Nuclear Power Plant Safety, which also includes research on the science and technology of maintenance and the role of public policy. Unlike other programs concerned with safe performance, the Safety Program's interests are in research, education, and technology transfer. Funded by private utilities and foundations, we are in contact with but receive no financial support from industry groups or government agencies such as INPO, NRC, DOE, and IAEA. Current Program sponsors are listed in Attachment 1.

The Nuclear Power Industry Executives Advisory Panel consists of senior managers actively concerned with important strategic and operational issues relevant to safety. The Panel contributes advice and comments to the Study Group, sharing their concerns and knowledge of plant operations and the national and international nuclear power industry as a whole. The Panel is a way for managers and researchers, collaboratively, to identify important issues for research with practical benefits. Active participation in particular research studies is one item on the Panel's agenda. Finally, where utilities are initiating organizational change, MIT may be able to offer support for research based around these change and implementation efforts.

Executives in utilities sponsoring the Safety Program, as

well as several others, were invited to the initial Panel meeting at MIT on April 22-23, 1992. The meeting's objectives were:

- To discuss issues and concerns at the strategic level of the nuclear power industry. For its first 18 months, the Study Group research has been primarily at the plant level, but now is considering as well the relationships to corporate levels and to regulators, suppliers, contractors, industry groups, and the labor market.
- To create additional channels of communication between the Study Group and sponsors to orient and prioritize the research and to contribute additional insights into our observations and interpretations.
- To examine strategic choices among research options and types of collaborative research, and the nature of near- and long-term research products, including the kinds of new knowledge that could be used to address important issues.
- To seek strategies for acquiring additional resources for the Study Group and the Safety Program. The ambitious goals of the Program and the opportunities for research made available by utilities exceed available resources.

The preliminary agenda (see Attachment 2) was structured to invite participants to raise and discuss their own issues and concerns, and to enable the Study Group to present their research strategies and plans for discussion. Included was an outline of possibilities for collaborative research, and discussion of specific next steps for the Study Group and the Advisory Panel.

#### Meeting Summary

The meeting began with introductions of 16 representatives from 6 U.S. utilities, two U.S. contractors, and utilities in Japan, France, and Korea, and 11 MIT faculty, research staff, and students. Attachment 3 provides a list of the participants.

Professor John Carroll positioned the Study Group's research within the nuclear power industry and the scientific study of

high-hazard industries. The Study Group is not a regulator or evaluator that assesses good and bad practices; nor is it a consulting group paid to solve problems. Instead, its distinctive contribution is to characterize the work of producing electricity in nuclear plants in terms of conceptual frameworks and self-design principles that can help those responsible for safe operations to design their own tools for solving their particular problems.

Nuclear power plants and other high-hazard technologies such as chemical production plants, airlines, some military operations, and bloodbanks pose greater management challenges for high-reliability operations (avoidance of errors, quick recovery from problems, and efficient learning from precursors and incidents) than the typical manufacturing or service organization. This places unusual pressure on training, employee vigilance, monitoring and quality controls, information flows, adequate resources, planning, and intergroup coordination.

The overall theoretical approach of the Study Group avoids the common "machine bureaucracy" and "compliance" images of nuclear power plants, which imply that there is one best way to manage. Instead, our research suggests that plant activities are better understood within a biological model (sometimes called ecological or open-systems) that considers continual innovation and change as essential properties of "living" organizations that must interact in an environment of other organizations and institutions. This image suggests that several organizational dimensions are important: cross-functional and other cross-boundary interdependencies; collective action; vigilance as a response to uncertainty; continuous learning; long-term investments in people and technology; and a recognition that management must tailor its practices to varying situations. This perspective further suggests that the effectiveness of "best practices" is enhanced by a thorough understanding of how practices taken from one plant can be tailored and modified for

use in a new organizational context.

The research strategy of the Study Group is distinctive because it reaches beyond a catalog of indicators with which to compare plant performance and prescribe procedures. Further, there is primary reliance on in-plant studies grounded in the details of how the work gets done and in the observations and interpretations of plant personnel throughout the organization and its environment, from maintenance workers to managers, design engineers, regulators, and suppliers. Although we have spent from one to four weeks in 17 plants in 6 countries, we recognize that intensive analyses of specific plants must be integrated with statements about large numbers of plants. Accordingly, Prof. Alfred Marcus from the University of Minnesota joined the Study Group to help create synergies between analysis of large quantitative data sets about plant safety and performance and grounded approaches in specific plants.

One objective of the Panel Meeting was to hear top managers express their own concerns and issues and to begin considering how these could be introduced into the research project. The MIT research team suggested 11 topics as possibilities for Roundtable (break-out) discussions, and the participants added 13 more topics of their own. Discussion of these possibilities reduced and combined them into six high-priority issues. Four topics were chosen for Roundtables: (a) compliance and autonomy; (b) cost control and safety; (c) plant aging and workforce changes; and (d) cross-functional and multi-site complexity. A fifth topic, managing change, was considered to cross-cut all the topics, and to be a part of each discussion. A sixth topic, public attitudes, was set aside with slightly lesser priority and less germane to the (current) research agenda. Reports from each Roundtable were later presented to the meeting as a whole. Ed Brown, former CEO of New Hampshire Yankee, enriched the discussion of utility concerns by providing an insider's perspective on the history of the Seabrook construction project.

Another objective of the Panel meeting was to discuss and provide strategic guidance regarding the research opportunities available to the Study Group. Each of the three principal MIT researchers in the Organization and Management Study Group outlined their studies and the opportunities presented by the project. In addition, Professor Donald Schon discussed how modes of collaborative research in which the Study Group participates in plant enhancement programs could satisfy both scientific and operating goals and build bridges between academic and practitioner approaches.

This report briefly summarizes the issues raised by Panel participants during Roundtables, presents the research possibilities and strategic issues from the MIT presentations, organizes the very rich interaction and general discussion, and closes with a summary of the possibilities raised by the participants for continued Panel activity and support for collaborative research.

#### Strategic Issues for the Nuclear Power Industry Compliance and Autonomy

Regulators tend to conceptualize safety as compliance with rules; INPO fosters an industry-wide culture of proceduralization and compliance. These detailed codifications and programs to ensure compliance have brought about great improvements in safety. The continuing trend is toward more explicit procedures, responding to both external and internal pressure to reduce risks. During operations, there is a tendency to do what the pieces of paper say, even if it is in conflict with what is believed to be right. People do not get in trouble for following the rules. When problems are encountered, the easiest solution is to fix the procedure to avoid that problem next time, thus making the procedures more and more explicit.

Blind adherence to procedure and compliance has the potential to create attitudes that are contrary to safety and performance in the long run. Heavy emphasis on proceduralization

can suppress ideas and originality; autonomy can increase pride, quality, and productivity. There is a desire in the nuclear power industry, shared in U.S. business in general, to push responsibility lower down into the organization and "empower" workers. This is partly to invigorate and motivate employees and foster thinking, but also acknowledges that procedures may never be so prescriptive as to be complete -- sometimes, doing the "proper" thing is not doing the "right" thing. Only a competent and vigilant workforce can recognize the difference and demonstrate "thoughtful" compliance. The Canadian operating policy and principles were said to stress thoughtful compliance, for example.

There was discussion of a role for the MIT Study Group to seek an independent understanding of how regulators understand standards and compliance; how employees feel about their jobs, the reward and recognition systems, and their understanding of why management does what it does; and international comparisons that could provide alternative models of procedure management.

#### Cost Control and Safety

The nuclear power industry experiences contradictory pressures to spend money and control costs. Regulators demand expensive security, maintenance work rules, and record keeping, for example; states impose costs for monitoring and telecommunication equipment. Competitive pressures from alternative power sources are substantial as nuclear operations and maintenance costs have been rising more rapidly; Public Utility Commissions only authorize investments if they can realize a lower price for power than from other sources. Since many costs are mandated, nuclear utilities are under pressure to cut wherever they can, sometimes including preventive maintenance and other fundamental activities.

There is a need to find a more rational budgeting process. Great variation exists in how budgets are constructed, including frequent turf battles and substantial subjectivity. Outages

often produce surprises that exceed target-based budgets. One bright spot is that new performance-based regulation at Pilgrim seems to integrate safety and cost by attaching bonuses to improved performance and safety indicators. Workers seem more attentive to safety issues than they were before implementation of these regulations.

Since TMI, investments in maintenance and technical fixes have increased capacity, but results from new investments in preventive maintenance and human resource issues are more difficult to quantify. The risks of additional investments are greater because aging plants may not get life extensions and may experience reduced performance. The industry needs analysis of the pressures to increase costs and the returns on investments. Some pressures are political, such as New Hampshire's insistence on real-time access to plant indicators, and Massachusetts' insistence that Seabrook install a \$6 million radio system.

The nuclear industries in Japan and France are under less financial pressure. Electricity costs are higher, there are no Public Utility Commissions, and borrowing limits are virtually non-existent because the state backs all loans. In Japan, there is pressure to reduce construction costs.

#### Plant Aging and Workforce Changes

Aging and the life-cycle of plants from construction to decommissioning is a major factor in this industry. Hardware undergoes changes with age; the embrittlement issue at Yankee Rowe is one example. There is an expectation that the upward progress of the industry must necessarily become increasingly difficult, since the easier and less expensive improvements have been done.

Since nuclear power industry workers rarely transfer to other industries and there is essentially no new power plant construction in the U.S., American workers are aging in their jobs with little upward career mobility. This suggests the possibility of boredom and demoralization. Aging workers may

also experience physical limitations, such as restricted vision and inability to handle stressful work, which places greater demands on job assignment and scheduling to recognize variable worker limitations. Workers in the nuclear power industry tend to dislike change; it is possible that older workers will be more resistant to change. Further, as workers retire, key knowledge may be lost. Those who really understand why the procedures are there get replaced by people who follow the procedures by rote.

Two other workforce problems were discussed. In Korea, workers must work in rural areas near the plants, yet all families want to live near Seoul so that the children can go to the best schools, which lead to the best careers. The result is family separation and considerable stress. In the U.S., new entries are a much more culturally-diverse group of workers than in the past, so that utilities have to manage the changing demographics and increasing diversity. The lack of female and minority top management in the nuclear power industry was noted.

There is a need to identify and evaluate human resource programs that can alleviate the above problems. For example, job redesign to enlarge responsibilities, creation of teams to do more tasks, job rotation, autonomy and participation, can have positive effects on worker motivation, substitute for upward mobility, and reduce concentration of key knowledge in aging workers. It was suggested that some existing programs may provide novelty by putting a "new face" or new label on work, or some job rotations may be a relief from routine rather than a learning experience. One possibility would be to increase peer visits within and between plants to share experience, learn from each other, and energize workers at all ranks.

#### Cross-Functional and Multi-Site Complexity

Nuclear power plants have a functional organization and, historically, the operations function was seen as most important. Recently, other functions, notably maintenance, have been recognized as important, as well as the management of cross-

functional, interdisciplinary teams and coordination across boundaries. The trend to decentralize staffs to plant levels is shifting to consolidation, for example, Bell South Utility and Southern.

The increased management involvement in maintenance is not seen as a basic change. Rather, there is a felt need for more management control, defined as better planning and preparation and keeping everyone informed after work is done, such as changes in the critical path of the work. The Swedish practice of block tagging out whole systems reduces the chances of error, and is being copied by some U.S. utilities.

Outage work is particularly complex. Seasoned teams at some utilities make good prioritization decisions about work items, others rely on predictive maintenance optimization programs. The Eletricite de France maintenance book is an important reference. Grand Gulf BWR in Mississippi had long outages, but last year completed one in 30 days. How did they do it?

Different levels of the plant have different understandings of the work. Managers should have technical knowledge, and many trained in Navy nuclear programs have thorough knowledge of operations, if they keep it up. Higher up in management, less detail is needed. Managers must listen to problem reports, and management systems that invite problem reporting are needed. Information systems can decrease complexity, reveal contradictions, and make information meaningful.

One problem area is procedure writing, which involves the transition from design engineering to procedure writing. The TVA, on completing its Belafonte station, has assembled a team with different skills to deal with the handoff. Procedure writing needs specialized startup engineers (roving consultants) to develop procedures and involvement of operators.

Can we find better, innovative approaches to organizing work from other industries, such as automobiles, manufacturing? The trend to empowerment is against NRC regulations only where it

changes the safety responsibilities.

### Regulatory Demands

Another element relating to the above issues, the actions of the NRC, surfaced in general discussion. Executives complain that the NRC is not consistent across regions in rule-making, fault-finding, and assigning penalties. NRC requirements shape the organization in ways that may limit approaches to safety. The NRC is perceived to be staffed with people who lack operating experience, and there is little transfer of staff between industry and regulators. Detailed analyses by management can receive unthoughtful responses and, for practical purposes, there are no grievance procedures or appeals from contested decisions. Yankee Rowe was seen as a case study of this process with details known only to insiders. It was suggested that the Study Group turn its attention to NRC management and organization. The one governmental agency that might share an interest in such a study is the Congress (through the Office of Technology Assessment).

Ed Brown's presentation of the Seabrook construction project also frames the "unfathomable maze" of the regulatory process. In the 17 years from construction permit application to operating license, two-thirds of the \$6 billion cost was attributable to licensing delays. He presented the strategic efforts to build credibility with the public and the Seabrook employees, deal with a wide range of constituencies with varied beliefs and demands, and establish a track record of striving for perfection that has ultimately led to a superior operating record. He concluded that the total regulatory framework in the U.S. makes constructing a plant in the U.S. too risky, unless and until credibility is rebuilt through safe, reliable operation; the spent fuel and waste issue is resolved; the public is convinced that fossil fuels are more harmful than nuclear; and the licensing process is made shorter and more predictable.

### Study Group Research Opportunities

#### Good vs. Troubled Pairs of Plants

It is natural to attribute plant performance to qualities of the people who staff and manage the plants. We have heard, for example, that plants are a reflection of the senior nuclear executives' level of involvement and personality. Workforces have been characterized as high or low on "work ethic" and general ability. Corporate culture is also mentioned.

However, we have observed interesting situations in which the same utility runs multiple plants with different performance histories. Sometimes, there is a "good performer" and a "troubled plant" sharing the same physical site, as defined by the utility itself (but also evident in performance histories). A comparison of such pairs of plants would be especially revealing because it focuses attention on the details of organization and technology in each plant. The sites are also interesting because various improvement strategies have been tried at the troubled plants, offering opportunities to examine change over time and implementation issues.

We have received invitations to conduct research at two such pairs of plants at two different utilities. We plan on-site data collection involving three interlocking studies carried out at the same sites: Organizational Pathways, Mental Models, and Improvement Strategies. Additionally, we are considering modes of collaborative research that would involve the Study Group in change efforts at these plants.

#### Organizational Pathways

Dr. Constance Perin discussed how the management of complex, interdependent technological systems of nuclear power plants demands that the activities of departments, divisions, and functions are coordinated. Managers balance safety goals with efficiency and production goals through a continuous exchange of resources along organizational pathways. These include production resources such as people, budgets, schedules, materials, and tools, and organizational resources such as mission, authority, information, experience, cooperation, and

status.

Nuclear power plants are particularly complex because the demands for coordination vary through the production and life cycles of the plants, including construction, commissioning, operating phases of power production and outage, and decommissioning. "For years we thought that an outage was the safest plant condition. Now we see that we do all the things that really matter to risk assessment analyses during refueling. We weren't smart enough to know that five years ago." Outage planning and implementation are critical for both safety enhancement and cost reduction, and require the highest degree of cross-functional coordination.

Mapping organizational pathways in outage planning and implementation will develop new knowledge about seven key issues: 1) learning from experience at all levels of the organization, including the use of industry "best practices" and management consultants' introduction of new organizational practices; 2) managing transitions between operating phases and tempos, including the potential for schedule pressure to create reward systems that penalize those who report safety concerns at the cost of immediate delays; 3) prioritizing resources and work items to balance efficiency and safety; 4) examining the unintended consequences of regulatory requirements, such as NRC pressures for disciplinary action against employees who err, and the tensions between proceduralization and autonomy; 5) considering life cycle issues such as the difficulty of obtaining replacement parts as plants age; 6) understanding the ways the organizational pathways lead off the formal organizational chart to the informal organization that springs up to accomplish the work; and 7) recognizing how knowledge is distributed across levels and functions, such as the separation between technical specialization and broad overview when both are needed to detect hazardous combinations that could penetrate defense-in-depth. The cases will provide data with which we can begin to

characterize organizational patterns and configurations as well as managerial strategies and processes that enhance safe performance, and develop helpful concepts and tools for organizational learning.

#### Performance Improvement

Prof. Alfred Marcus discussed the processes underlying efforts at performance improvement that have contributed to the enhancement of performance and safety in the past decade. Performance improvement relies heavily on learning from operating experience, which includes problem recognition and programs of remedial action. The "big" problems faced by nuclear utilities, which emerge from regulatory requirements, international events such as TMI and Chernobyl, more local incidents, financial competitiveness, and performance comparisons, have solutions that are hard to find and expensive to implement.

All organizations tend to respond to problems by selecting from an existing inventory of solutions. In the nuclear power industry, common solutions are realigning corporate and plant relationships through structural changes to the nuclear department, upgrading plant positions and programs, seeking successful management models such as the Navy supervisory model or the McKinsey Seven S's (Structure, Strategy, Systems, Shared Values, Skills, Style, Staff), bringing in new outside leadership, buying management training, copying new management approaches (such as empowerment), and focusing on measurable indicators of performance and cost.

On the one hand, these activities facilitate improvement. They reflect the changing needs of organizations, continuous adjustment to feedback, flexible management that admits there is no "one best way" to manage and must weave together these different approaches. On the other hand, these activities may inhibit improvement by creating distractions from or resource competition with basic tasks such as learning from experience, preventive maintenance, outage planning, and making key operating

decisions. Management needs to continually consider how to assure a better fit between problems and solutions, while keeping aligned the solutions to small and big problems.

The opportunities for intensive investigation of problem diagnoses and change implementations at several plant sites can provide detailed cases of organizations coping with these critical processes.

### Mental Models

Prof. John Carroll discussed how identification of plant conditions, diagnosis of underlying problems, and design of programs of corrective action, are based on interpretations made by plant personnel who possess somewhat overlapping yet distinct understandings of the technical and human systems in plants. These understandings or "mental models" of plant operations are distributed among occupational groups and different levels of experience. Effective interpretation and change management requires the marshalling of these distributed partial models. Therefore, it is reasonable to conclude that a feature of "good" plants will be mental models that individually and collectively diagnose problems effectively.

Some of the assumptions and character of these mental models is readily apparent. The industry has long relied on models that analyze technical systems into components and focus on parts, suggest technical fixes, use hardware redundancy as a major safety feature, pay attention to man-machine interfaces, and focus blame on individual human error or lack of attention to detail. More recently, the industry has wrestled with organizational issues that reach into the social and cultural systems in plants, utilities, and the industry as a whole. The models most frequently encountered include control from the top, nuclear executives shaping their organizations in their image, "compliance" through strict proceduralization and division of labor by expertise, hiring quality people and training them, sharing problems and "best practice" solutions, problem analysis

through "root cause" methods, and problem resolution through corrective action programs.

Although the above images have been usefully employed to improve industry performance, the available vocabulary of mental models suggests some shortcomings. Missing are details about the managerial, social and cultural systems in organizations comparable to the details of technical systems and individual human error. For example, at one plant a very thoughtful task force leader shared his concern about the "philosophy" of the NRC. He believes the NRC focus on "problem resolution" tends to put plants in the position of waiting for difficulties to emerge, at which time solutions are generated to address the problem, ie., problem resolution programs begin with problems. He compared this to putting on band-aids. He prefers a concept of "process improvement" that he sees as more proactive and capable of introducing more fundamental and timely changes. This is a different mental model of change, and requires more attention to the details of plant organization and work processes.

For the most part, "mental models" of plant operations are implicit. They are rarely discussed or formally presented. They emerge as the foundation of the interpretive work that occurs around problems, incidents, or issues that create surprise, concern, or a need to know more. In short, mental models are revealed as they are used. As people in the plant discuss and analyze such issues together, they are exposed to each others' mental models, and each person's own models becomes more general, more comprehensive, and more consistent and closely linked with others' models.

In order to understand better these interpretive and learning processes, we present to employees for their analysis a small number of interesting examples from actual situations in plants, as reported in Lifted Leads and Nuclear Network. The employees are in different hierarchical levels, divisions, and occupations, across a range of plants. Each person is asked to

discuss the causes and conditions underlying the situation, what further information they wish to have, what would happen in their plant following such an incident, and what they would recommend as responses. Currently, pilot testing of the materials is underway at one nuclear power plant.

We will examine the nature and distribution of categories and language in these "mental models" across functional areas and hierarchical levels in plants and utilities. The volume and variety of analysis, the attention to systemic, social, and cultural factors, and the degree to which ideas are shared across functional and hierarchical boundaries can be related to plant performance.

#### Forms of Collaborative Research

Among the possibilities for research are opportunities for intensive collaboration on projects initiated by plants themselves. One mode of research, called "action research," has employees define problems they wish to solve and create interdisciplinary teams with outside researchers on the team. The advantages are: the researchers have additional observational opportunities in a cross-functional project that is working to effect change, which should be a rich source of insight about the organization, barriers to change, and strategies to overcome the barriers; there are opportunities for immediate feedback about the researchers' ideas including the effects of including these ideas in action programs; and the researchers are forced to be action-oriented, to bridge the gap between abstract generalities and concrete realities, and thereby transfer both explicit theories and technologies, and more implicit knowledge and methods.

This is a resource-intensive mode of research; each such engagement would be a lengthy commitment of dedicated personnel. Further, it must be maintained in a research, not a consulting, framework. Discussion pointed out that such work would be most valuable if carried out in two or three places in the U.S. and

abroad. One possibility is to collect data on all three projects from the same two or three sites in Year 3, although other related studies may involve short visits and remote data collection from additional plants.

Prof. Donald Schon provided some frameworks for considering different forms of collaborative research. He observed that the Panel members expressed a desire to be more involved in the research through access to stories and research observations so that they can form their own interpretations, to theories that help make sense of the situations, and to ideas and practices about intervention and change. The issue, then, is how to design a learning process as a collaborative effort of researchers and sponsor employees involved in incident reviews.

The research model of normal social science typically assumes that the researcher is a distant and objective observer whose task is to create models from a generalizable body of scientific knowledge. The scientist writes a book that a manager finds suggestive of answers to problems; the manager hires a consultant who forms a team to apply the knowledge. However, even in situations with available scientific knowledge, the implementation process is likely to distort or ignore such knowledge. Researchers and consultants are not just distant observers of plants; when their reports are unused, they are part of the problem.

The process of implementing research findings in an organization is likely to be much more reliable and productive when: (a) the practitioners are involved in generating the data and forming and testing ideas about it, and (b) the implementation process is itself conceived as an continuation of the research process in which new applications and new theories can be generated to deal with new phenomena (including resistance to change) that crop up during implementation. Thus, collaborative research supports the dual goals of improving performance and advancing science.

In order for all this to work out, the practitioners have to be interested in trying to make the process work -- something they are much more likely to do if they have a hand in constructing the ideas they are trying to implement and if they believe that they can influence these ideas in the course of implementation. The collaborative relationship is structured to capture the local "hands-on" knowledge of practitioners close to the working situation, to create commitment from those who are formulating the application and carrying out the intervention, and to empower people who must use the results of the research. Further, the collaborative relationship makes the researchers more central as observers of and contributors to the implementation process.

Teams of practitioners can become action researchers who invent and test new strategies of problem solving or intervention and design organizational structures to facilitate work, which are likely to enhance their effectiveness. Prof. Schon gave the example of a Rand project on the Sage system which found (in a situation with fast, iterative, and publicly-available performance feedback, extended time to learn, and rewards for improved performance) that when structural constraints (procedures and roles) were removed, work teams invented their own, more efficient social solutions to communication and learning, and greatly improved their performance.

Action research raises fundamental issues of organizational structure, cooperation, authority, blaming, fear, shame, and embarrassment. The very top of the firm has to be prepared to face these issues, and support their discussion in the research and implementation teams. For example, the failure of a large-scale communications network turned out to be due to a latent software bug: one misplaced punctuation mark in a program with millions of instructions. When that error was traced back to its root causes, many issues surfaced. Among these was the fact that the network had become extraordinarily complex, indeed, beyond

any one individual's understanding, because it was being customized to meet the needs of many different users. Underlying the network failure, then, was a dilemma involving market responsiveness vs. network reliability. But within the organization, this dilemma was undiscussable: People feared they would lose their jobs if they insisted on raising the issue. This example suggests that fear, shame, embarrassment and threat can impede the reliable functioning of organizational learning systems. An effective program of action research must treat such phenomena as objects of inquiry.

It would be immoral to embark on collaborative research designs unless the length of time commitment was sufficient and top management is willing to listen to the results with an open mind and sincere commitment to solve the problem. Such commitment is facilitated by paying part of the cost of the research, since someone has to work the issue through the organization to authorize payment, which paves the way for further authorizations of change.

#### Prospects for Further Collaboration and Panel Activity

Several Panel members expressed a desire to be more directly involved in the Study Group research. Discussion ranged over ways to create more involvement, including providing the Panel with more of the unprocessed observations of the researchers for comment and interpretations, creating a more succinct statement of the theories and models being developed by the Study Group, and writing case-like materials on our research observations to be used as communication and educational materials. The issue of confidentiality of plant identity was discussed, and seemed to be manageable. The Study Group was exciting by this expression of cooperation and desire to share knowledge, and will work on ways to pursue these ideas.

There was considerable support for more intensive collaborative modes of research, and recognition of the considerable resource commitment they entailed. The Panel agreed

that such activity should retain a research focus, rather than a consulting focus. Accordingly, it would be appropriate to have part of the costs paid by the research sites, and to have multiple sites to maintain the clarity of research focus.

The Panel recognized that the strategic choices for the Study Group were also questions of resource allocation and resource acquisition. It was hoped that additional resources could be found, and research designed such that intensive collaborative research could be carried out along with less-intensive data collection from other plants. Additional resources may depend on demonstrable products from the research, making it incumbent on the Study Group to put its ideas, its observations, and its preliminary interpretations in a form that can be readily communicated to the Panel and to current and prospective sponsors. The Panel expressed great interest in and willingness to help shape such products. Also, the Panel suggested that "products" should be thought of broadly, including our theoretical approaches and our observations as well as our conclusions and any research-based recommendations or new programs. Finally, the Panel encouraged the ideas of studying the organization and management of the NRC (which has not been subject to study by GAO or others).

The Study Group was asked to issue a report or proceedings of the Panel meeting for general distribution, as rapidly as possible. To ensure accuracy and confidentiality of particular statements about plant incidents and performance, a preliminary version of the report is to be sent out for comment to all Panel participants before release as an MIT research report. The Study Group will also develop materials communicating our approach and observations for comment by the Panel, and work toward "case-like" materials as a vehicle for our observations, a means for eliciting the interpretations and viewpoints of the Panel, and a management training tool.

Attachment 1 - Program Sponsors

<u>Country</u>	<u>Organization</u>
Finland	Imatran Voima Oy Teolisuuden Voima Oy
Germany	Kraftwerk Union AG
Japan	Mitsui, Inc., Ltd. agent for: Chubu Electric Power Company, Inc. Japan Atomic Power Company Kansai Electric Power Company, Inc. Kyushu Electric Power Company, Inc. Tokyo Electric Power Company, Inc.
South Korea	Korea Electric Power Corporation
Switzerland	Swiss Nuclear Operators Group
Commonwealth of Independent States	Institute of Nuclear Safety of the Academy of Sciences of Russia
United States	Boston Edison Company Commonwealth Edison Company Consumers Power Company Duke Power Company EG&G, Inc. Florida Power and Light Company General Electric Company The John D. and Catherine T. MacArthur Foundation New York Power Authority The David and Lucile Packard Foundation Public Service Electric and Gas Company Stone and Webster Engineering Company Yankee Atomic Electric Company
International	World Association of Nuclear Operators - Paris Center International Atomic Energy Agency - Division of Nuclear Safety

Attachment 2 - Advisory Panel Agenda

WEDNESDAY, APRIL 22, 1992 E56-Penthouse

- 2:00pm Introductions  
Study Group Overview: Prof. John S. Carroll
- 2:45 Advisory Panel Members' Concerns  
General Discussion
- 3:45 Coffee
- 4:15 Issue Prioritization
- 4:30 Issue by Issue Roundtable Discussion
- 6:00 Break
- 6:30 Reception and Dinner, Cambridge Marriott Hotel
- 8:00 Speaker: Edward A. Brown, Retired Chairman and Chief  
Executive Officer, Yankee Atomic Electric Co.  
and New Hampshire Yankee

THURSDAY, APRIL 23, 1992 E52-598

- 8:30am Coffee
- 9:00 Organization and Management Study Group  
Presentations and Discussion
- 1) Current in-plant studies and preliminary  
observations: John S. Carroll, Constance Perin,  
Alfred Marcus
  - 2) Research options:
    - a. International collaborations (France, Japan,  
European Community, Eastern Europe)
    - b. "Action Research" design and implementation:  
Prof. Donald Schon
- 10:30 Coffee
- 10:45 Research Prioritization Discussion
- 11:30 Planning for Next Meeting
- 12:00 Departure (members of the Study Group and Faculty Advisory  
Committee will be available for further discussion)

Attachment 3 - Panel Meeting Attendees

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