Management Research on Outages and Maintenance

John S. Carroll
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Alfred A. Marcus

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THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY
INTERNATIONAL PROGRAM FOR ENHANCED NUCLEAR POWER PLANT SAFETY

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Report of the Second Panel Meeting
Nuclear Power Industry Executives Advisory Panel
MIT Sloan School of Management
Cambridge, Massachusetts
March 18-19, 1993

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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 second Panel meeting, representatives from nuclear industry organizations in six countries met with MIT faculty, research staff, and students to engage in a collaborative analysis and interpretation of observations collected by the Study Group. This was in response to the first Executives Advisory Panel's desire to be more directly involved in the Study Group research.

Study Group faculty presented for discussion five brief statements of frameworks being developed to understand organization and management issues in nuclear power plants: the Ecological Model, the Activities Model, Mental Models and Incident Reviews, Organizational Improvement, and System Dynamics. The core of the meeting was the analysis of two detailed sets of observations from Study Group research on: (1) outage planning and management, and (2) plant improvement efforts and maintenance, including demonstration of the Maintenance Game developed by Du Pont Chemicals to represent the complex interactions among maintenance, operations, and support services.

Discussion ranged across specific observations presented by the Study Group and interpretations and comparisons raised by Panel members from their own extensive knowledge of the nuclear power industry. The open and constructive atmosphere led to a variety of insights and suggestions. Finally, next steps were detailed for continued communication between the Panel and the MIT Study Group.

Organization and Management in the Nuclear Power Industry

Report of the Panel Meeting
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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. With these frameworks, utility and plant management can design management systems and work processes that can help them 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. The Safety Program's interests are in research, education, and technology transfer, not in evaluation. Funded by private utilities and other organizations in the nuclear power industry as well as 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, the Study Group may be able to offer support for research based around these change and implementation efforts.

Executives from sponsor organizations of the MIT Safety Program were invited to the second Panel meeting at MIT, held on March 18-19, 1993. The meeting's objectives were:

- To collaborate on the discussion and interpretation of observations collected by the Study Group on two topics: (1) outage planning and management, and (2) plant improvement efforts and maintenance.
- To clarify the assumptions and implicit theories that both researchers and panel members use to make their interpretations.
- To contribute additional insights regarding the Study Group's observations and interpretations.

The agenda (see Attachment 2) was structured to invite participants to collaborate with the Study Group in the ongoing development of research frameworks and interpretation of observations from the Study Group research, and to raise and discuss their own issues and concerns for discussion. Included was a discussion of specific next steps for the Study Group and the Advisory Panel.

Meeting Summary

The meeting began with introductions of 11 representatives from three U.S. utilities, two U.S. contractors, utilities in Japan, Korea, Switzerland, and Finland, and the World Association of Nuclear Operators - Paris, and 8 MIT Study Group faculty, research staff, and students. Attachment 3 provides a list of the participants.

Professor John Carroll discussed the purposes and agenda for the meeting. He 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 management 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 (LaPorte & Consolini, 1991; Roberts, 1990; Weick, 1987). This places unusual pressure on systems design, training, employee vigilance, monitoring and quality controls, information flows, resource allocation, planning, and intergroup coordination.

Ecological Model

Prof. Carroll outlined the overall theoretical approach of the Study Group, which seeks to integrate the traditional "machine bureaucracy" and procedural compliance model of nuclear power plants with an "ecological" or open-systems model 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 our current understanding of nuclear power plants as organizations must be enhanced by additional concepts:

- cross-functional and other cross-boundary interdependencies must be considered along with top-down control;
- awareness and vigilance as responses to uncertainty belong alongside compliance;
- continuous learning is as important as standardization;
- work systems and organizational pathways that are "off the chart" contribute along with functional groups and lines of authority;
- long-term investments in people and building a community belong with efforts to motivate individual effort and drive out slack;
- distributed expertise and its synthesis in problem recognition and solving need to be cultivated along with technical specialization by discipline; and
- the organizational and technological systems of nuclear power plants are continually being improved by learning from feedback, and evolving from their original design.

Discussion pointed out that external factors greatly affect plant priorities, such as the high cost of supporting NRC personnel on site.

The uncertainties and decentralization implied by the ecological model are uncomfortable to many who consider control and compliance as the way to manage nuclear power plants. In an interview at one plant, an employee suggested that the plant could not be understood fully as a standard organizational chart (Figure 1a) or the machine bureaucracy (Figure 1b, Mintzberg, 1979). Instead, he proposed a set of intersecting circles (Figure 1c). When we showed his suggestion to a manager from another utility, the manager recoiled in distress: "If you let people out of their boxes, you will have chaos." His reaction reveals how difficult it is to introduce concepts of flexibility and interdependence into traditional models of functional division and top-down control. Yet, many utilities are trying to do this, for example, the (partial) chart of organizational arrangements at an Electricite de France plant (Figure 1d) that shows an inner ring of core functions around the plant manager, and an outer ring of services that circulate around the inner ring, with groups connecting and contracting with each other fluidly as required by the tasks.

Technical models of complex systems, such as PRA analyses of nuclear power plants, define a safe envelope given the assumptions of the models. However, analyses of serious events in shipping, railroads, chemicals, and nuclear power suggest that the most serious problems emerge when the system is outside its design basis, and that workers and managers may not know when this boundary is being approached or passed (Rasmussen, 1990). Defense in depth in the nuclear power industry means that ineffective barriers are not easily detectable. Yet, people manage risks when they "touch the boundaries" and experience feedback. When radar was developed to make ships safer in bad weather, the effect was to permit higher speeds without increased safety; similarly, anti-lock brakes on cars can lead to higher speeds and more abrupt stops rather than to increased safety.

Work practices, including the way we manage with safety, are developed at local levels. Despite detailed procedures and training, some aspects of the work are always in the hands of the workers. Work practices are responsive to several influences: the nature of the work itself and getting the job done; pressures for speed and cost-cutting; unforeseen obstacles to overcome; and experience with good and bad outcomes. However, because the work pressures and economic pressures are more tangible and concrete than the boundaries of safe performance, there is a tendency to slip toward the edge of the envelope without knowing where the boundary really is. More importantly, there is ignorance about where others are in their own work processes (see Figure 2). This is one reason that it is difficult to manage collective or system-wide safety issues when work practices tend to edge toward the boundary at local spots. This suggests a need for ways to help people see the individual and collective boundaries of their everyday work. Discussion linked this to the practice of intentionally entering a limited condition of operation (LCO) in order to perform cost-effective maintenance on line by spreading workload between outage and normal operations.

Activities Model

Dr. Perin outlined the "Activities Model" (Perin, 1993) of nuclear power plant organizational and managerial processes, a model based on observations of work systems and their relationships -- "the ecology of work." The model also represents management's job of aligning the flow of complex technological processes with the flow of human and organizational processes that support them. The Activities Model contrasts with positional and functional models that represent plant operations by organizational charts that delineate hierarchical and functional relationships. While such models and charts explain the distribution of authority and accountability, the activities model helps to explain safe performance by representing the ways that plants are run and maintained and how their organizational systems support error prevention and recovery.

The model recognizes the central role of the "informal" organization as it appears in the activities of numerous cross-functional and cross-level teams, task forces, and committees. These activities represent the plant's efforts to align human and organizational processes with technological factors for maximum safety and efficiency, for which a key organizational concept is the "program." Program activities bring functions and levels together to assure that a set of activities with a particular goal are well planned and executed. They require collaboration across expertises and across the territories of standard functions (administration, maintenance, operations, chemistry, etc.) Typical plant programs are:

safety and emergency services
on-site and off-site safety review

regulatory compliance
preventive maintenance
surveillance and testing
technical services
industrial safety
licensing
planning and scheduling
quality assurance
configuration management
radiological protection
security
fire protection
emergency plans
heat balance improvement
safety review and audit
quality control and assurance
environmental qualifications
environmental monitoring
hazardous waste
chemical material control
training
external audits

Such program activities reveal many kinds of bridging processes between organizational levels, specializations, production cycles, shifts, and handoffs, which are particularly vulnerable to miscommunication and incomplete information. In creating these bridges, plant employees reveal their shared understandings of both the technical and organizational logics that need to work together. Through program activities, actors convert organizational charts into maps that show the locations of gaps and junctions. Members of the panel cautioned, however, that programs may themselves be only "bandaids" used to patch over systemic flaws in organizational policies. These flaws may result from the inability of functional and hierarchical models to account for the policies and practices that help to maintain the balance between safety and efficiency.

One goal of an activities model is to help plant and utility staff to describe their own organizational gaps in order to develop the policies and strategies needed for bridging them. Gaps are conceptual, administrative, and operational; they occur on many levels -- for example, between old and new procedures, between designers' intentions and how they prove themselves in operation, between functions, between corporate headquarters and plant production facilities, and between safety achievements and maintaining them, and between systems design and operation, operating and life cycle phases, contractors and organizational employees, management and unions. Discussion suggested some of the benefits of shifting from functional job structures to project classifications, and highlighted the potential resistance of middle-managers who may fear losing their authority over a turf or a set of subordinates.

Outage Planning and Scheduling Observational Set

Dr. Perin described how the Organization and Management Study Group continues to concentrate research on outage issues. Outages have been recognized only recently to be a substantial source of risk; they are also a time of great complexity and stress, when work is done that is crucial for reliable operations between outages. She raised the question of how conventional project management models fit the needs of outage planning and scheduling. They concentrate more on content and control agendas than on the process agenda for assuring clear communication and coordination.

Panel members were asked share outage experiences and observations by discussing utility, plant, and regulator perspectives on issues and to comment on post outage critiques made by employees at a U.S. nuclear power plant and the viewpoints of U.S. utility and plant managers and the U.S. regulator (Attachments 4 and 5). Many comments, especially by European Panel members, supported delegating responsibility downward in order to save time, reinforce ownership and planning at lower levels, and reduce the need for QA and QC; trust, vigilance, attention, pride, open-mindedness are the glue of organizational systems, and those lower in the hierarchy are sometimes better judges of safety and better able to identify ways to improve safety and reduce problems, as in an example of a U.S. plant where workers suggested permanent power feeds for outage work. Quality of skills and understanding at the craft level was an important issue and source of comparison across countries, although these difference are both inputs from educational institutions and products of plant cultures. U.S. members agreed that elevating issues up the line creates bottlenecks -- indeed, problems tend to be solved in hallway meetings rather than formal meetings.

Relationships between corporate headquarters and plants in the field are sometimes characterized by efforts to decentralize or centralize, and by a sense of mutual misunderstanding. Managers at higher levels make decisions, such as resource allocations, that have consequences for risk that they did not foresee. In general, flows of information are difficult to manage; there is too much and too little. Information tends to be filtered according to actual consequences rather than possible consequences.

The Panel suggested that plants were never designed to be shut down -- all Tech Specs are for full power operation, and there is no simulator training for shutdown; however, some plants (including Russian designs in Finland) are designed for access and maintenance, thus avoiding damage and system malfunctions from taking components apart for inspection. Even clear Tech Specs leave room for interpretation. In older plants as employees retire or leave, loss of organizational memory contributes to poor configuration control and poor communication. PRA can help to eliminate weak links in plants, and may provide warning signals, but it is not a measure of safety.

Mental Models

Prof. Carroll presented a framework for considering nuclear power plants as learning organizations, in which improvement depends upon the ability to interpret the meanings of operating experience from within and outside the plant. The management of risk involves learning to identify and reduce entry into precursor situations and to recover rapidly from deficiencies. Although the need to transmit information throughout the industry is well understood in the post-TMI era, our understandings of how plants seek, receive, interpret, and use information for plant improvements are not fully developed. "Organizations in which reliability is a more pressing issue than efficiency often have unique problems in learning and understanding which, if unresolved, affect their performance adversely" (Weick, 1987, p. 112).

Knowledge of the plant's technical and organizational systems is distributed across occupational boundaries and levels, with different groups having partial understandings or "mental models" that must be combined and revised to prevent and address problems. Specialists need accurate technical knowledge: the wrong physical models in training, procedures, and operator interpretation contributed to the events at TMI; their lack of operational knowledge at Chernobyl led inexperienced engineers to defeat safety systems and procedures. Yet specialists need training beyond their own specialty: designers, procedure writers, operators and craft employees have different views, needs, and knowledge with which they "train" one another. Social and organizational systems that guide the intersection of technical specialties and social know-how are more difficult to design than a model of tech specs or a PRA analysis. What works with machines -- design, control, redundancy -- may not work the same way with people. The real power of new ideas in manufacturing such as Total Quality Management and design for manufacturability are the social systems that encourage communication, mutual respect, and cooperation among technical and occupational specialties and up and down hierarchies.

The mental models prevalent in the nuclear power industry tend to be more formal and individualistic than substantive and social. They focus on technical fixes, component reliability, avoidance of individual error, leadership, and problem resolution programs such as incident review/root cause analysis/corrective action. These mental models do not represent key social and organizational elements such as communication, authority, social relationships, and conflicting goals. They do not account for the co-occurrence of individual action and situational conditions, nor do they model the ways that dynamic relationships play out over time. Further, they do not acknowledge the importance of interpretive skills and opportunities for utility and plant personnel to integrate their specialized knowledge through visits and travel, meetings, task force participation, job rotation, and so forth.

Panel discussion considered how flows of information about plant conditions and experiences are affected by management practices. Punishment and blame does not help information flow: Russian plants use lots of punishment, and then people tend to cover up more. Rewards do help make it easier for people to tell about mistakes. Root cause analyses too easily turn into root blame analyses. Job rotation can give people broader experience and create more information flow, such as from administration to operations and vice-versa, maintenance foreman to planning to training and back, engineer to shift experience and back (letting new engineers "kick the tires" during outage). It is difficult to rotate people across pay levels and from corporate to site and back; accurate career previews become essential.

Performance Improvement and Organizational Problem Solving

Prof. Alfred Marcus discussed performance improvement processes that have contributed to the enhancement of reliability and safety in the past decade. A conceptual model of improvement was presented that identified these causes of current performance: past performance, identification of problems, resource availability, resource application, strategic choices, experience, and production technology.

Empirical studies of performance and process indicators from 58 U.S. nuclear power plants during the 1980s showed that past performance (scrams, safety system actuations, safety system failures, major violations, SALP scores, radiation) was a strong predictor of future performance, so that plants seem to get into positive and negative performance streams; once in a negative stream, it is difficult to improve. However, several additional factors influence changes in performance over time, including better financial health (return on investment), less spending per megawatt capacity (it is possible to be safe and efficient), more spending on supervision and engineering operations per megawatt capacity but less on supervision and engineering maintenance per megawatt capacity (these are FERC budget categories), and higher percentage of utility power generated by nuclear (Marcus, Nichols, & McAvoy, 1993).

Lively discussion focused on whether the accounting numbers can be considered comparable and meaningful across different utilities and plants. They budget very differently and put different expenditures into broad categories reported to FERC, PUCs, etc. It may be very difficult to know what underlies measures such as "spending on supervision and engineering operations" without detailed statements from each utility. However, the overall relationships are suggestive of some underlying features that should be investigated further.

System Dynamics

Dr. Carroll presented an approach to thinking about and representing complex, dynamic processes that unfold over time, in which causal factors are themselves altered by their own effects. Complex systems are tightly coupled, have multiple feedback structures with long delays, have counterintuitive cause-effect relationships distant in time and space, and exhibit different short-run and long-run behavior. Thus, well-intentioned solutions to problems may actually worsen the situation in the long run (Senge, 1990).

Examples of complex systems that are difficult to predict and control because of these dynamics include the national debt, which generates both pressure to cut spending and interest payments that increase spending, and the real estate market, in which investors consistently misestimate market dynamics leading to boom and bust cycles. In nuclear power plants, a natural response to maintenance-induced component failures is to increase the number of rules and degree of procedural detail. In the short run this may increase maintenance quality, but it may also demotivate and deskill craft workers, and cause better workers to leave, thus potentially reducing maintenance quality in the long run. The overall impact of rule proliferation and proceduralization is therefore difficult to predict or assess.

Plant Improvement and Maintenance Observational Set

Dr. Carroll presented observations from a plant site that has been visited several times by the Study Group (Carroll, Sterman, & Marcus, 1993). This site fits the Study Group research plan of comparing a plant with a consistently good operating history and a plant with a troubled history run by the same utility.

At Peninsula Haven (a fictitious name for the site), there is an older plant and a newer plant (which we call Colonial and Alexander Grant) with dramatically different operating histories. The utility has made numerous efforts to change Colonial's procedures, equipment, leadership, and culture. These change efforts included bringing in an ex-Navy VP-Nuclear, writing new procedures, establishing new reward and promotion practices, using many outside consultants, shifting key personnel from Alexander Grant, and upgrading equipment and housekeeping. Yet, at the same time, the utility was demanding cost-cutting and reducing budget, especially at Colonial in comparison to Alexander Grant.

Despite these efforts and a sense of improvement, Colonial never quite seemed to get ahead; new problems keep cropping up. NRC and INPO conveyed a negative impression of Colonial that harmed morale. Overdue preventive maintenance lagged behind Alexander Grant and the rest of the industry. Following a great year with its best performance ever, Colonial suffered serious equipment damage when three protection valves failed due to improper maintenance. The vendor did not require preventive maintenance, other plants and Colonial had experienced malfunctions of the valves (although without damage), and commitments to replace the valves at the next outage were slipped due to an outage schedule burdened with a great deal of overdue preventive maintenance.

The difficulty in managing preventive maintenance and keeping the proverbial small problem from suddenly growing big is not unique to the nuclear industry; it represents a general deficiency in "mental models." Dr. Carroll related how Du Pont Chemicals discovered it had developed a culture of reactive maintenance in which people expected failures, spent more on maintenance than other companies, yet had less availability than other companies (Carroll et al., 1993). Heavy cost-cutting pressures resulted in cuts to preventive maintenance and planning, since corrective maintenance must be done; yet these cuts led to more corrective maintenance and a vicious cycle. Throughout industry, attention is focused more on operations than on maintenance. Plants are understood as decomposed functions rather than integrated systems. As a result, people have difficulty understanding the relationships among functional areas and the long-term effects of reward systems and cost-cutting pressures that focus on the short term.

At Du Pont, numerous change efforts also failed. Then, one team created a system dynamics model of the complex relationships and demands. This model showed that reductions in maintenance costs do not necessarily reduce total costs because maintenance has complex links to other functions that were not well-understood in the company. The teams efforts to convey their new understanding through traditional workshops were unsuccessful. Instead, they created a "Maintenance Game," played on a game board with elaborate rules and roles, that simulates the relationships among operations, maintenance, and support functions. Two Sloan School Masters Degree students, Elizabeth Gorman and Mark Hardie, showed the game equipment, demonstrated the various steps in the game, and explained how it has been used in workshops at the Sloan School and at Du Pont. Discussion centered on the applicability of the game to the nuclear power context and ways nuclear power plants differ from chemical production plants.

A workshop built around the game has been taken by over 1500 Du Pont employees and has changed the way people from the shop floor to the executive suites think about maintenance. It formed the basis for a new program of pump maintenance that has substantially improved reliability while reducing costs. However, the lessons of the game still meet resistance, due to expectations of overtime pay, mistrust between planners and workers, resistance to giving up exciting corrective work for dull preventive work, and fear of layoffs.

Panel members saw parallels between Colonial and other plants, especially those built before TMI. Members disagreed about the difficulties of creating change from within as compared to using outside consultants. Panel members suggested that Peninsula Haven needed more analytical planning and more resources in general, although members disagreed about the linkage between manpower and performance. Panel members also differed on the relative contributions of technical and managerial problems: some issues seem to represent purely technical issues. It is difficult to separate sources of problems, or to characterize plants as good or bad, although some plants have more flexible designs that permit ease of maintainability.

Prospects for Further Collaboration and Panel Activity

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. Panel members thought that case studies were a good way to keep everyone "on the ground," and they expressed interest in continuing to track Peninsula Haven to gain further insight.

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Attachment 1 - Program Sponsors

Country	Organization
Finland	Imatran Voima Oy Teolisuuden Voima Oy
France	Electricite de France
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
Russia	Institute of Nuclear Safety of the Academy of Sciences of Russia
United States	Commonwealth Edison Company Consolidated Edison of New York 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 Southern Nuclear Operating Company Stone and Webster Engineering Company Yankee Atomic Electric Company
International	International Atomic Energy Agency - Division of Nuclear Safety

Attachment 2 - Advisory Panel Agenda

Thursday, March 18

8:30am Introduction

- A. Welcome
- B. Design of this workshop
- C. Discussion of Agenda

9:00am Study Group Conceptual Frameworks I

- A. Ecological Model
- B. Activities Model

10:15am Coffee Break

10:30am First Observational Set

Outages are a difficult phase for a plant -- challenging, hectic, dangerous, expensive, and essential for a good next run. The Study Group will present outage observations from bottom-up and top-down in plants, and compare these with industry overviews of the issues involved. Panel discussion will share interpretations and seek to identify assumptions and models that are used to understand and manage outages.

12:00am Lunch Break

1:00pm Continuing Discussion

3:00pm Coffee Break

3:30pm Study Group Conceptual Frameworks II

- C. Mental Models
- D. Organizational Problem Solving
- E. System Dynamics

5:00pm Break for Dinner

6:00pm Cocktails at Davio's, Royal Sonesta Hotel, Cambridge

7:00pm Dinner at Davio's

Friday, March 19

8:30am Second Observational Set

The Study Group has visited a site with one well-performing plant and one poorly-performing plant. The utility has made significant efforts over many years to improve the troubled plant, but these have not fully succeeded. We will discuss these improvement efforts, the barriers to change, the difficulties with maintenance in particular, and some similarities to "The Maintenance Game" at Du Pont Chemicals.

10:00am Coffee Break

10:15am Continuing Discussion

11:30am General Discussion

What surprises, interesting insights on familiar phenomena, and new principles have surfaced in the workshop? Have we succeeded at communicating our interpretations and searching out underlying assumptions? How should we design the next iteration?

12:30pm End of Workshop

Attachment 3 - Panel Meeting Attendees

Dr. Henry E. Bliss
Director of Advanced Technologies
Commonwealth Edison
1400 OPUS Place, Suite 650
Downers Grove, IL 60515

Dipl. Ing. Hans M. Achermann
Elektrizitats-Gesellschaft Laufenburg AG
CH-4335 Laufenburg
SWITZERLAND

Dr. Bjarne Regnell
Corporate Advisor
IMATRAN VOIMA OY
P.O. Box 112, 01601 Vantaa
FINLAND

Mr. Jacques Burtheret
Director, WANO-PC
35 Avenue de Friedland
75008 Paris, FRANCE

Mr. John W. Landis
Senior Vice President & Director
Stone & Webster Engineering Corp.
P. O. Box 2325
Boston, MA 02107

Dr. Harold Blackman
EG&G Idaho
P.O. Box 1625
Idaho Falls, ID 83415

Mr. Louis Liberatori
Consolidated Edison of New York
Broadway and Bleakley Avenue
Buchanan, NY 10511

Mr. Richard E. Skavdahl
GE Nuclear Energy
Services General Manager
175 Curtner Avenue MC 792
San Jose, CA 95125

Mr. Maeng Kyu Kim
Manager, Technology Planning Section
Korea Electric Power Corp.
187 Samsong-Dong, Kangnam-Gu
Seoul, 135-791 KOREA

Mr. D. N. Morey
General Manager - Farley Project
P.O. Box 1295
Birmingham, AL 35201

Mr. Yoshihiro Horikawa
The Kansai Electric Power Co., Inc.
1100 17th Street, Suite 500
Washington, D.C. 20036

Prof. John S. Carroll
MIT Sloan School of Management
50 Memorial Drive
Cambridge, MA 02139

Dr. Constance Perin
MIT Sloan School of Management
50 Memorial Drive
Cambridge, MA 02139

Prof. Alfred Marcus
Carlson School of Management
University of Minnesota
Minneapolis, MN 55455

Mr. George Roth
Center for Organizational Learning
MIT Sloan School of Management
50 Memorial Drive
Cambridge, MA 02139

Ms. Bhavy Lal
MIT Department of Nuclear Engineering
77 Massachusetts Avenue
Cambridge, MA 02139

Ms. Petra Klumb
Berlin University of Technology
MIT Sloan School of Management
50 Memorial Drive
Cambridge, MA 02139

Mr. Francisco Silva
MIT Sloan School of Management
50 Memorial Drive
Cambridge, MA 02139

Mr. Taiji Yamaoka
Chubu Electric Power Co.
Visiting Engineer
MIT Energy Laboratory
Cambridge, MA 02139

Attachment 4

OUTAGE CRITIQUES

How much detail does each level of management need to know? At your level, which of these comments would you find helpful for the kinds of decisions you need to make? Why these?

Nuclear power station employees in the US wrote these comments in response to the outage manager's request for contributions to a post-outage critique (standard practice throughout this utility). He asks for several kinds of feedback, e.g., "actions by individuals or groups that exemplified...teamwork philosophy"; "success stories"; "good practices"; "things that didn't go so well...areas in which you feel there is room to improve"; and "how the outage manager can provide a service or product that will help you get your work done a little easier. Also if I did something that was helpful and you would like to see it continued that would be nice to know."

1) Comment by Maintenance Crew member, handwritten and signed with his extension number and name of his supervisor.

This work order states in the work information section that Maintenance is to place N2 [nitrogen] bottles for Operations Steam Generator work. This means that maintenance is to procure eight bottles of 300 cu.ft (99.99% pure) nitrogen from the warehouse. These bottles weigh about seventy-five to 100 pounds each. The bottles are to be routed to lower containment. They are then relocated to four transmitters (two bottles per transmitter) located at the base of each accumulator room in the pipe chase.

The problem here lies in the fact that not only is it difficult to get eight bottles of nitrogen in the pipe chase, but extremely hazardous to have to drag these same bottles around to each of their proper locations. All of this, incidentally, is to purge the steam generators during draindown. This work order is the second time this process was done (due to a conoseal leak). This means that sixteen bottles had to be drug around the pipe chase (thirty-two if you count removing each bottle). The reason I'm saying all of this is that there has got to be a better and safer way to accomplish this objective, without endangering someone's life.

Here's a few suggestions. Granted, I'm not really sure how well any of these will work, or if anything can be done about this problem. But, if you could look into this, Maintenance would be greatly appreciative. Here's the suggestions. The unit supervisor on our shift suggests utilizing a penetration that's obligated for [to]

> outage work. Another station has a permanent penetration, piped and tested, just for this setup. The unit supervisor stated that there are several penetrations delegated but not used that may serve our purpose. Our SRO [senior reactor operator] suggests that it may be feasible to use the six hundred cubic ft. of nitrogen in the accumulators. This would need more research though.
>
> That's about it technically from this end. Anything you could come up with, or any safer way to do the job as it is now, we would be glad to here it.

2) These comments are excerpted from a 10-page single-spaced computer document consisting of: 69 separate items on the just-completed outage; 12 critique items outstanding from previous outages; and 19 items suggesting improvements to the process; no "good practices" or "success stories" were cited.

> 30. Need a written philosophy on block tagout boundary change. Work was held up on a KC A train by not changing the boundary. OPS cleared the tags and issued a new tagout.
>
> 33. The NSM [nuclear station modifications] process needs looking into. We didn't follow the new revision of the OMP. We almost violated containment closure due to a hole was drilled into a S/G [steam generator]. A procedure change to the closure PT's was found laying on someone's desk that should have been implemented weeks earlier. If the new process had been followed by implementing the procedure change when the work order associated with the hole went working, this would not have happened.
>
> 35. Need a tasting plan for the end of the outage. We had to create the logic when we got there.
>
> 37. Everyone needs to understand that for MOVATS [motor-operated valve testing], static conditions must exist in the piping to obtain data. We were unable to perform MOVATS on [one valve] in the prescribed schedule window because we had flow through the pipe.
>
> 45. We need a predefined work order to troubleshoot airlocks since we have so many problems with them during the outage. Has anyone looked into replacing the airlock controls with better ones so that we don't have the problems we have?
>
> 52. In the Startup Procedure, Mechanical Maintenance has to sign to verify that all penetrations are sealed prior to Mode 4 entry.

> This signoff is not needed since the PCMC list should have all work orders coded for MOde 4 concerning this item. MM spent many hours trying to verify something the PCMC list already did.
>
> 57. Need to change the Unit 2 drain procedure exactly the way we had the Unit 1 procedure changed this outage to allow us to establish NC chemistry in an expedient manner.
>
> 63. Need to have specific guidance in management procedures as to what items will turn over on station and which will not. Several times during the outage, supervisors were reluctant to start jobs near shift turnover even though they were critical path items (i.e., injecting N2 into the S/G's ~6 hour holdup).
>
> 69. No real water management program in place. I felt like it was handled but it could have been smoother with a procedure or schedule guidance.

3) Excerpt from the outage log, which was submitted with his critique by the manager of Instrumentation and Control:

> Since starting fill and vent this time it seems that there are a lot of "oh by the ways" coming up that keep delaying the expected time to mode 4 and then mode 3 and then CA testing. Is there some way that someone can look ahead and identify all this stuff so it can be done off critical path? And another thing, it seems that Ops Unit Managers Group should be able to provide a plan to the shift and the plan work equally well and on schedule no matter the Shift that happens to be on. How can we do this? Should this plan be developed in the outage schedule, if not, why?

HOW UTILITY, PLANT, AND REGULATOR STAFF VIEW OUTAGE ISSUES

Do you see these as being significant issues? What others do you think merit attention?
Why do you agree or disagree with the reasons each gives for their occurrence?

UTILITY PERSPECTIVES (drawn from utility study)
Issue: Tech Spec Violations during cold shutdown and startup:

- Technical failures in signal and alarm systems (no warnings or erroneous warnings)
- Personnel failure to heed signals
- Poor communication between functions

Reasons for violations and for increases in incidents:

- Better information feedback leads to more detection
- Exceeding LCOs due to increased complexity of rules
- Tech Specs poorly understood outside of Operations
- Violations may be detected in timely way, but preventing their recurrence is organizationally complicated and therefore slow to materialize

PLANT PERSPECTIVES (drawn from post-outage critiques)
Issue: Prioritization

- Items identified in previous plant outage critiques do not get prioritized and worked on
- Not enough attention given to Work Order priorities
- Procedures affecting outage work aren't approved on time
- Preoutage work included in outage schedule that eats manpower and time

Reasons:

- Outage schedule logic not clearly articulated
- Station modifications arrive late in the process
- Not all functions participate adequately in schedule development

Issue: Above-Goal Radiation Exposures

- Decisions made to begin work without adequate analysis; performing test mode changes while waiting for analysis; performing S/G work prematurely....
- Saving time during test modes increases exposure

Reasons:

- Budget concerns making it more difficult to control exposures
- Management decisions made as best business decisions, but disturbing from an ALARA perspective.
- Upper management not sufficiently involved in planning, scheduling, and execution improvements needed to lower doses.

REGULATOR PERSPECTIVES (drawn from NUREG 1449 draft)
Issues:

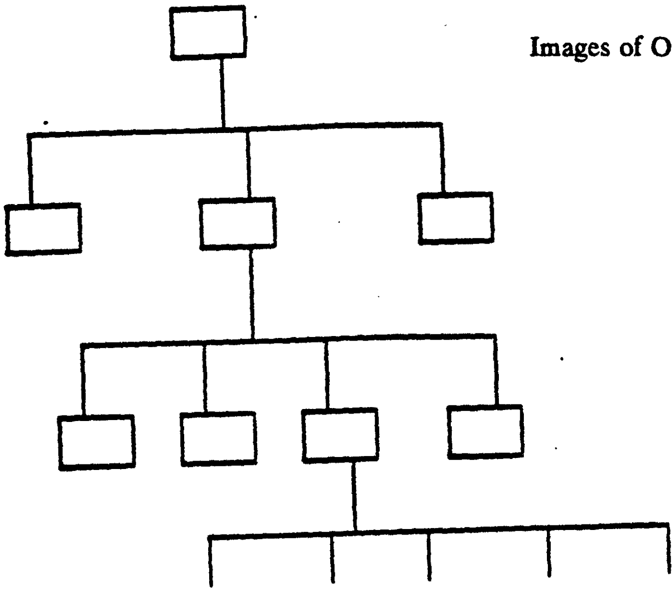
"The staff concludes that a more safety-oriented approach to outage planning and control which includes the following elements would substantially reduce shutdown risk.

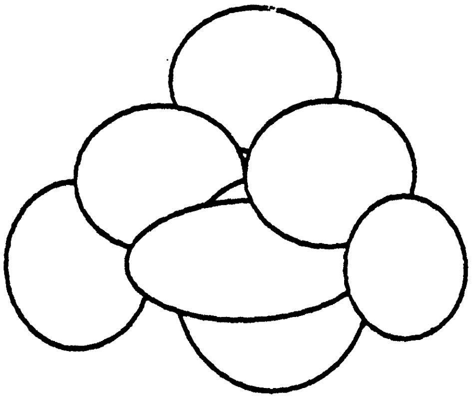
. clearly defined and documented safety principles for outage planning and control
. clearly defined organizational roles and responsibilities
. controlled procedure defining the outage planning process
. pre-planning for all outages
. strong technical input based on safety analysis, risk insights and defense in depth
. independent safety review of the outage plan and subsequent modifications
. controlled information system to provide critical safety parameters and equipment status on a real-time basis during the outage
. contingency plans and bases
. realistic consideration of staffing needs and personnel capabilities with emphasis on control room staff
. training
. feedback of shutdown experience into the planning process" (pp. xvi-xvii).

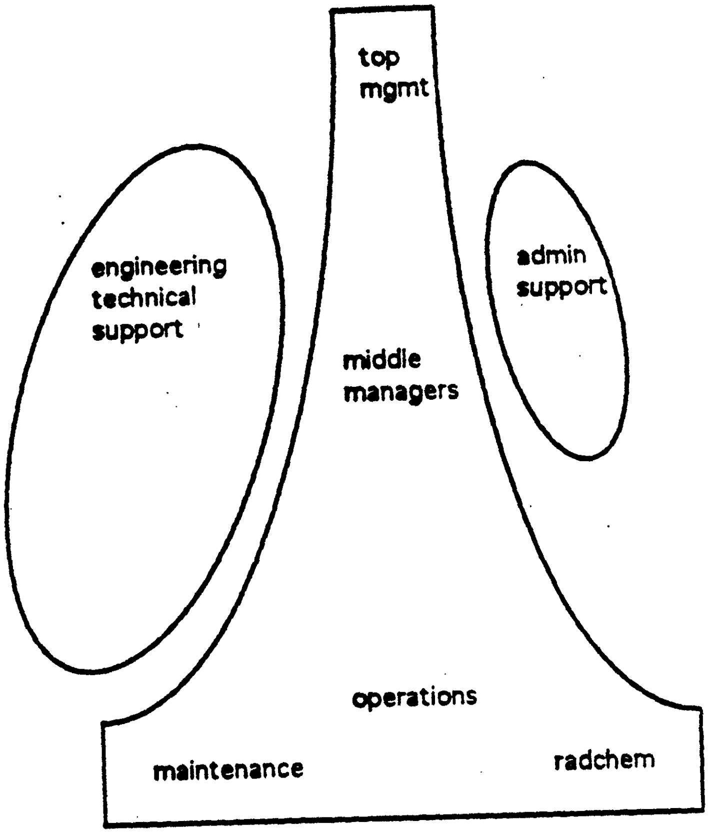
Reasons:

"Outage planning and control is considered to be the most important issue related to shutdown risk because it effectively establishes if and when a licensee will enter circumstances likely to challenge safety functions and, in the absence of technical specification controls, establishes the level of mitigative equipment available to respond to such a challenge. A wide variety of programs currently exists. Safety principles and practices are included in some programs, but a rigorous basis for them was rarely noted" (p. xvi).

Figure 1
Images of Organizational Structure







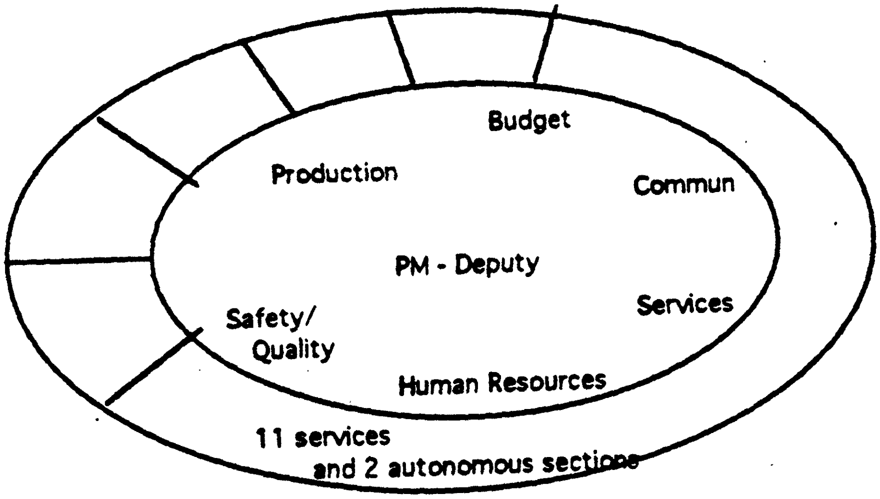


Figure 2
The Operating Envelope Defined by Work Load, Efficiency, and Safety