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Research Paper - Significance Culture in Nuclear Installations

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From: Constance Perin <cope@MIT.EDU>
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Date: Thu, Jun 16, 2005 11:11 AM
Subject: Research Paper for Commissioners

Please distribute to all Commissioners a copy of my paper, "Significance Culture in Nuclear Installations," presented on June 6, 2005 at the Annual Conference of the American Nuclear Society. As an invited paper on the NISD panel, "Regulating Safety Culture," it addresses issues that Commissioner Lyons and other NRC attendees considered at the conference. I welcome their comments.
I've attached the paper in both .doc and .rtf formats.
Thank you very much! Could you please send confirmation that you've received and acted on this request? Many thanks --
Constance Perin

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American Nuclear Society
2005 Annual Meeting, San Diego, CA
Nuclear Installations Safety Division
Panel, "Regulation of Safety Culture"
June 6, 2005

Significance Culture in Nuclear Installations

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Significance Culture in Nuclear Installations

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"Paradigm Shifts" Past, Present, Future

In 1998, Robert J. Budnitz, then chair of the American Nuclear Society's Nuclear Installations Safety Division, pointed out that it has "taken a very long time to understand the key factors" controlling the adequacy of safe nuclear operations." Moreover, their importance shifts with "new information and changing circumstances." The "new environment" of deregulation "is a powerful force," Budnitz said, "bringing about changes in the management and culture of many" licensees. Without the rate base cushion, he foresaw, managers will use "different criteria" in scrutinizing "safety expenses," and that "has, by itself, changed everyone's perception of the relative importance" of key issues. And "specifically, the management/safety-culture issue comes to the fore as one requiring careful monitoring and review." Further, considering "whether to repair or replace" becomes "very much tied up" with those issues. "The need to confront the technical issues involved with aging plants is challenging enough," even without deregulation, Budnitz said. [1]

To those earlier "paradigm shifts," as Budnitz calls them, today we have to add global security issues and the consequences of the Davis-Besse revelations of 2002. And the NRC response to aging and deregulation: first with the Maintenance Rule in 1991 and by April 2000 with a revised Reactor Oversight Process (ROP). With the paradigm shift to "performance-based" and "risk-informed" regulation, the industry sought more "objective" and less deterministic oversight to reduce its capital costs and costs of compliance. The NRC sought to reduce its budget and staff as

well. In any case, NRC inspections historically have accounted for only about five percent of a plant's equipment and programs. "Self-regulation," the NRC says, is "its fundamental building block." [2]

To explain my proposal for a next paradigm shift to "significance culture" requires a brief overview of NRC's Reactor Oversight Process. Quarterly plant assessments occur in two stages. The first consists of inspections of the conditions of elements in seven "cornerstones" of reactor safety, defined by the design basis and accident precursor scenarios. After combining these with plant-reported "performance indicators" for each cornerstone element, the NRC makes its findings.

In the second stage, the NRC subjects its findings to a formal Significance Determination Process (SDP) to characterize the level of "safety significance" of the performance of each cornerstone's elements, using "risk insights, where appropriate." The SDP allows licensees to provide their "perspectives" on NRC's findings and to submit further information before it decides on its quarterly plant ratings (white, green, yellow, red) and enforcement actions.

This Reactor Oversight Process also acknowledges the presence of three "cross-cutting areas": Corrective Actions Programs (Problem Identification and Resolution), listening to Employee Concerns, and Human Performance. But NRC does not require performance indicators for these "areas," nor may NRC inspectors report "qualitative" observations unless they can show substantively that a program's deficiencies relate to specific outcomes in specific cornerstones. [3]

These cross-cutting programs, the NRC's Advisory Committee on Reactor Safety decided in 2004, represent the Commission's framework for monitoring "safety culture." Any "broader evaluations...such as management emphasis on safety and personnel attitudes, belong to the industry." [4] But as of 2005, according to the chief of NRC's Performance Assessment Section, it is also these programs that "generally manifest themselves as the root causes...identified in findings and violations." [5]. Nevertheless, NRC's sampling inspections of these programs occur only every two years. All these programs are mainly self-regulated, but their effectiveness appears to be a general problem: at Electricité de France, between

2001 and 2004, the causes of events have remained stable as has their number: 25 percent, material failure, 40-50 percent, human error, and 35 percent, "organizational failures." [6]

The construct "safety culture" is, such data suggest, under-specified for the weight it carries. I propose that focusing instead on "significance culture" -- the necessity to characterize the risk-levels of conditions and processes -- requires a knowledge-centered paradigm for operating circumstances today and in the foreseeable future. That is, to characterize safety-significance requires curiosity, free flows of information, reliable analyses, and open exchanges among differing perspectives from shop floors to executive suites, between contractors and staff, and across myriad specialists. When those are missing, as event analyses often show they are, they are now likely to be attributed to "human error" and "organizational failure."

Significance culture arises out of a knowledge-using and knowledge-creating paradigm. Its effectiveness depends less on "management emphasis" and "personnel attitudes" than on having an operational philosophy represented in goals, policies, priorities, and actions organized around effectively characterizing questionable conditions before they can escalate risk. However a knowledge-centered paradigm may be elaborated, its goal in this industry is to be commensurate with the conditions and challenges of aging fleets and start-ups, as well as uprating, upgrading, digitizing, and security -- and all that, within the context of worldwide concerns with retention and recruiting.

Origin of Significance Culture

By 1991, in the aftermath of Chernobyl (1986), the IAEA introduced to this industry a concern with "safety culture," defining it as "that assembly of characteristics and attitudes which establishes that, as an overriding priority, nuclear plant *safety issues receive attention warranted by their significance.*"[7; my italics] That qualifying caution sums up the process by which "nuclear safety" is maintained: "significance" thereby overrides the "overriding priority" of "safety issues." That puts "safety culture" under the control of significance culture.

Warranting significance is one kind of process when inspection findings refer to the design basis or cornerstones. The points of reference for determining conditions' levels of significance are Accident Precursor Scenarios, PRAs, and nuclear safety principles. Warranting significance is another kind of process during operations, when it also takes account of contingent or pragmatic matters of schedule, budget, and configuration control. That is, there is an official Significance Determination Process and an operational Significance Determination Process. After events, analyses may call into question decisions resulting from either or both processes.

Licensees face a constant quandary: at the same time as preventive and corrective maintenance or upgrading protects the system, these activities can also perturb configuration control, escalate risk, and reduce time on line, hence profits. Protect, perturb, produce: licensees continually make trade-offs among these simultaneous imperatives, whether planning outages, evaluating unusual vibrations in a pump, or revisiting "campaign items" pending with local citizens, the NRC, and INPO assessors. There are always grid obligations and budget and resource limitations. Although U.S. licensees' quality assurance programs are bound by statute to have the "required authority and organizational freedom, including sufficient independence from cost and schedule when opposed to safety

considerations," oversight specialists may not always be party to the satisficing or negotiating process of significance determinations. [8]

That process usually begins with assigning each condition report a significance level – annually at any one plant, these can number in the thousands. Priorities of and resources for subsequent event reviews, root cause analyses, and corrective actions depend on managers' determination of the "attention" a condition warrants in light of operational priorities as well as design basis issues.

To clarify how its managers and experts handle this process during and after an event, Electricité de France initiated "The Nuclear Safety, Availability, Radiation Protection and Environment Observatory" as a "tool for optimizing safety in terms of major decisions," and for identifying good practices and discovering where there is room for improvement. In effect, its staff revisits operational SDPs at corporate, executive, departmental, and field levels. Its mission is to "guarantee the primacy of nuclear safety" yet "optimize" the way in which plant and company experts and managers consider every other element. The Observatory staff focuses on how event participants "reconciled" or "arbitrated" the "requirements linked to nuclear safety, availability, radiation protection, and the environment" -- "availability" referring of course to market pressures. [9] The same self-regulatory process could also be used for nonevents, those dicey situations in which decisions led to positive outcomes.

Both licensees' and NRC's Significance Determination Processes define and reflect corporate, plant, and regulatory significance cultures. We know little about their systematics in the United States, given the industry's longstanding aversion to research into "organizational" and "managerial" factors. One study, however, documents the significance cultures of Northeast Utilities and NRC as played out at Millstone Power Station in the 1990s. Paul MacAvoy and Jean Rosenthal, of the Yale School of Management, show in their new book, *Corporate Profit and Nuclear Safety: Strategy at Northeast Utilities in the 1990's*, how the Northeast Utilities' executive management group pursued a trade-off strategy of noninvestment in "repair and replacement" to anticipate price competition under deregulation, and they also show how NRC did not anticipate its operational consequences. While that strategy succeeded for the balance sheet and rewarded executives monetarily, it led to the

company's collapse, the largest fine in the industry's history, and the sale of Millstone's three reactors. [10]

Preconditions of Production

"The reason we're here," say some at nuclear plants, "is to produce electricity!" Or, at weapons sites, to meet cleanup targets. To reach those goals at least risk to employees and publics requires that hundreds of preconditions be met. One fundamental precondition, events and accidents tell us, is the capacity to recognize and characterize the risk significance of early warning signs. That requires a reliable stream of information and analysis of system conditions and, no less, knowledge of operating experiences elsewhere. As engineers Walter H. and Thomas C. Esselman warn, such data for supporting the industry's goal of fewer and shorter outages in aging plants are likely to be "subtle," and "only an unusual level of cooperation among operations, maintenance and engineering" can provide it.

> As performance improves, the factors that detract from performance will become much more subtle. *A dramatic improvement in the way that plant data are used should be sought.* That includes data recorded by computers, and from system engineer walkdowns, operator rounds, predictive monitoring, surveillance tests, inspections, and many other sources of information. [11; my italics]

"Low-level events" and "near misses" are often overlooked sources of such "subtle" knowledge about system conditions. So are unimplemented corrective actions. But even when discovered and warnings made, that knowledge may not be shared or evaluated. [12] Think of ignored warnings about nozzle leaks. Think of events where operating experiences were neglected. Think of handoffs or prejob briefs when information fell through the cracks. Think of managers with limited knowledge who misunderstand technical analyses and can't ask the right questions.

Corrective Actions Programs: An Eighth Cornerstone?

Significance culture demands reliable knowledge, whether new or old, subtle, simple,

or complex: trend lines, a PRA, a "significance and consequences" tool. Perhaps the most important source of new knowledge about plant conditions is the Corrective Actions Program (Problem Identification and Resolution). Condition reports and event reviews document not only material issues. Uniquely, they also document systemic interactions among people, priorities, and equipment — feedback not otherwise available.

But licensees' self-regulation of their Corrective Action Programs may be inadequate, suggests a 2001 NRC study of events involving "human reliability" at U.S. nuclear power plants between 1992 and 1997. Of 37 events involving safety-critical systems, not only had event reviews not identified earlier uncorrected errors, but failures to correct already known problems came to light, gaps four times more numerous than errors in the event itself. Evidence of failures "to monitor, observe, or otherwise respond to negative trends, industry notices [of equipment defects and recommended revisions in operating practices], or design problems...contributed to 41 percent of the events." [13]

The longevity of faults and defects, to some experts, is more worrisome than their frequency. Under a knowledge-centered paradigm, Corrective Actions Programs would not be positioned as a nontechnical (nonmeasurable) "cross-cutting area." They would instead become another cornerstone for which performance criteria and indicators would be required, in hopes of a "dramatic improvement" in the subtle and new knowledge available from this technically indispensable feedback system. [14]

Further, a knowledge-centered paradigm would, as a matter of *self-regulation,* expect licensees to extend the other two cross-cutting areas of "human performance" and "employee concerns" to the activities and priorities of executives and managers in their operational SDPs, as EDF's Observatory does. The Northeast Utilities case clearly shows that human performance programs do not reach "human error" in executive suites and board rooms, nor do reactor risk analyses take into account such managers' "human reliability." The kinds of knowledge and analysis that operational SDPs have been found to require would become performance criteria for such self-regulation.

Knowledge-Centered Efficiency, Productivity, and Safety-Significance

Consider how much else about operations and production would come into sharper focus if the knowledge demands of significance characterization were the organizing principle of operations. New kinds of efficiency and productivity questions arise. For example, how high are the knowledge exchange barriers among the dozens if not hundreds of plant programs producing and using information for each other? And barriers among specialists in their different disciplines and among managers in their different locations and offices? In all risky technologies, the record shows that entrenched professional turfs, rigid hierarchies, lack of collaboration, and neglect of operating experiences are among preconditions implicated in accidents and serious events. [15]

If a knowledge-centered paradigm were the conceptual basis for operating complex, hazardous technologies, technocracies and machine bureaucracies organized by functions and hierarchies would disappear. Instead, their structures would reflect the distribution of resources and competencies for supporting the production, analysis, and exchange of knowledge needed to pinpoint significance,

acknowledge trends, and make sense of anomalies and contingencies. There are few other kinds of enterprises where it as urgent to do that efficiently and effectively – certainly, our national security system springs to mind.

Significance culture contrasts markedly with safety culture, as the industry (NRC and licensees) now understands it. "Safety culture" seems to consist of little more than the industry's initial obligations and its own loss-prevention and oversight goals. The frequency with which it is necessary to call attention to such nuclear safety basics suggests that the fossil mentality is not yet a relic of nuclear power's early days. A paradigm shift to knowledge-centered operations for the timely characterizations of risk-significance is commensurate with the challenges of dealing maturely not only with aging fleets but with the many start-ups of "old" design reactors in the coming years. Think of Three Mile Island (1979), Davis-Besse (2002), Mihama-3 (2004) [16].

In their proposal for this ANS panel, NISD members restated NRC's concerns: that an emphasis on a "safety conscious work environment" and "too aggressive a regulatory approach toward safety culture will intrude upon the prerogatives of management and exceed the expertise of the regulatory body." Under performance-based and risk-informed regulation and the renewed obligations of self-regulation, the "prerogatives" and knowledge needs of regulators and licensees have become more similar. In 1998, Robert Budnitz remarked that "what we once called management [we] now call safety culture." [17] In 2005, it seems to be time to call the management of nuclear installations by another, more significant, name.

References

[1] Budnitz, Robert J. 1998. "Message from the Chair." *NISD Newsletter.* Spring, pp. 1-2.

[2] U.S. Nuclear Regulatory Commission. Detailed ROP Description. "Assessing Plant Performance." 2005. http://www.nrc.gov/reactors/operating/oversight/rop-description.html

[3] U.S. Nuclear Regulatory Commission. 2003. NRC Inspection Manual, Manual Chapter 0609, Issue Date 3/21/03. 8 pages.

[4] Mario V. Bonaca, Chairman, ACRS. Letter to NRC Chairman Nils Diaz, "Subject: Safety Culture." July 16, 2003. The ACRS concluded that while quantifying safety culture was not feasible, the ROP framework nevertheless adequately "monitors" safety culture and that "broader evaluations...such as management emphasis on safety and personnel attitudes, belong to the industry." http://www.nrc.gov/reading-rm/doc-collections/acrs/letters/2004/5142088.pdf

[5] Andersen, James. 2005. "ROP/Cross Cutting Issues." Chief of NRC's Performance Assessment Section. NRC Regulatory Information Conference, March 9. p. 3.

[6] Kovan, Dick. 2005. "2004 Operating Nuclear Facility Safety: Successes and Challenges." *Nuclear News*. January, p. 53, quoting Jean-Loup Rouyer (EDF).

[7] International Atomic Energy Agency. 1991. *Safety culture*. Safety Series. International Nuclear Safety Advisory Group (75-INSAG–4). Vienna: International Atomic Energy Agency.

[8] U.S. Code of Federal Regulations, Part 50, 10CFR, Appendix B, section 1.

[9] Miniere, Dominique. 2004. Electricité de France, Deputy Senior Vice President for Nuclear Power Operations. Presentation, *"The Nuclear Safety, Availability, Radiation protection and Environment Observatory `SAREO' at EDF. A tool for optimizing safety in terms of major decisions."* IAEA-International Conference on Topical Issues in Nuclear Installation Safety, Beijing, China, 18-22 October 2004.

[10] MacAvoy, Paul W. and Jean W. Rosenthal, 2005. *Corporate profit and nuclear safety: Strategy at Northeast Utilities in the 1990s*. Princeton: Princeton University Press.

[11] Esselman, Walter H., and Thomas C. Esselman. 2000. "Nuclear power: Viable in a competitive market?" *Nuclear News*. January, p. 51.

[12] Knowledge issues arose in two EDF Observatory cases, for example. In one, there was "insufficient dialogue between operations and maintenance teams, as well as a lack of understanding regarding the safety criterion" for operating a particular valve. In a second, although "information was properly conveyed to staff" and "a

perfect track was kept of the decision....the site was not proactive in preparing for exchanges with corporate technical support," and "communication with the regional regulator [about technical details] was insufficient." See Miniere, Dominique. 2004. [8].

[13] U.S. Nuclear Regulatory Commission. 2001. "Review of findings for human error contribution to risk in operating events," pp. xi-xii. Prepared by David I. Gertman, Bruce P. Hallbert, Mark W. Parrish, Martin B. Sattision, Doug Brownson, James P. Tortorelli. Idaho National Engineering and Environmental Laboratory. August. NUREG CR-6753.

[14] Wright, Gary. 2005. "Top Three Challenges/Solutions for CY2005." NRC Regulatory Information Conference, March 8, p. 5. Wright, assistant director of the Illinois Emergency Management Agency, Division of Nuclear Safety, made this suggestion after observing that the "PI&R program receives too little NRC attention under the Baseline Inspection program."

[15] A Nuclear Installations Safety Division data collection and teaching project exemplifies a knowledge-centered initiative. The goal, Paul Amico says, is to capture original design rationales otherwise being lost as experts retire or leave the industry. The project intends to pass on "a broad base of knowledge about why we do certain things." "It's possible now," Amico says, "to challenge the conventional wisdom and question the safety requirements. But how can we formulate the right questions if we don't have a complete understanding of how we got there in the first place?" [15] Amico, Paul. 2004. "Message from the Chair." *NISD Newsletter*, p. 1. Fall.

[16] Werdine, Humberto. 2004. International Atomic Energy Agency, Senior Safety Officer. "Proactive safety management strategies related to the operating experience process." Presentation, IAEA Conference. Beijing, 18-22 September.

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A cultural anthropologist specializing in the study of professional work, knowledge, and value systems, Perin has held Guggenheim, Fulbright, and Ford Foundation fellowships and visiting appointments at universities in the United States and abroad. Since 1983 she has done most of her research at the Massachusetts Institute of Technology, and from 1990-1995 was a member of an MIT International Program to Enhance Nuclear Power Plant Safety study. She is currently a visiting scholar in MIT's Anthropology Program.