INEL-95/00080
CONF-950434--4

ORGANIZATIONAL SAFETY FACTORS RESEARCH LESSONS LEARNED

Thomas G. Ryan

Idaho National Engineering Laboratory

ABSTRACT

This paper reports lessons learned and state of knowledge gained from an organizational factors research activity involving commercial nuclear power plants in the United States, through the end of 1991, as seen by the scientists immediately involved in the research. Lessons learned information was gathered from the research teams and individuals using a question and answer format. The following five questions were submitted to each team and individual: (1) What organizational factors appear to influence safety performance in some systematic way, (2) Should organizational factors research focus at the plant level, or should it extend beyond the plant level to the parent company, rate setting commissions, regulatory agencies, (3) How important is having direct access to plants for doing organizational factors research, (4) What lessons have been learned to date as the result of doing organizational factors research in a nuclear regulatory setting, and (5) What organizational research topics and issues should be pursued in the future?

Conclusions based on the responses provided for this report are that organizational factors research can be conducted in a regulatory setting and produce useful results. Technologies pioneered in other academic, commercial, and military settings can be adopted for use in a nuclear regulatory setting. The future success of such research depends upon the cooperation of regulators, contractors, and the nuclear industry.

Each in its own way can be expected to be a beneficiaries of the results. By regulators for moving beyond educated speculation to assessments of plant safety performance that are not only objective but instructive to both the regulators and the plant. By the licensees for self improvement. By the contractors, especially the 12 universities currently involved in the work, to collate and expand on the findings to the benefit of commercial, public, and military operators of complex high reliability socio-technical systems.

DISCLAIMER

1. INTRODUCTION

This paper reports lessons learned and state of knowledge gained from an organizational factors research activity involving commercial nuclear power plants in the United States, through the end of 1991, as seen by the scientists immediately involved in the research. The primary sources of information for this paper were 15 teams of people and individuals which conducted a total of 14 organizational factors projects. More specifically, these projects were staffed by 85 subject matter experts within two U.S. national laboratories, five U. S. private consulting firms, 12 universities, two U.S. national research academies and institutes, one foreign research institute, and industry based peer review groups.

This paper is needed and deemed timely to serve as one basis for future research in this area. This paper provided the teams and individuals an alternative forum for presenting their perspectives beyond those normally conveyed in formal project reports.

2. BACKGROUND

Abnormal events and accidents inside and outside the commercial nuclear industry, both in the United States and abroad, have suggested that institutional or organizational factors play an important role in the safe operation of complex high reliability socio-technical systems. Recognizing this fact, a United States regulatory agency initiated a organizational factors research program during the 1980s directed toward the development of: (1) analytic tools and data to support both regulator and licensee initiatives in this area, and (2) a better understanding of the factors that shape organizational performance as it pertains to safety. Its primary products could include improved: (1) methods for modeling, gathering data, and quantifying the influences of Organizational Factors on plant risk, and (2) indicators of plant safety performance. Spin-offs of the research are believed to be capable of supporting other licensing, inspection, and diagnostic evaluation activities within the regulatory agency. Finally, potential products of this research could be useful to the plant operators in self monitoring and optimizing their safety performance. This paper presents the lessons learned from this research through the end of 1991.

Generally, organizational factors research is based on a belief that hierarchically related groups, rather than individuals, operate and respond to off normal nuclear power plant events. Therefore, the regulatory agency research focused on the total plant organization, formal subdivisions of that organization down through the team level, technical support programs such as maintenance and training believed to significantly influence overall plant safety performance, and on selected functions and roles. Function and roles such as management are also believed to significantly influence plant safety performance.

Through 1991, lessons learned and findings from the research were used to support a variety of regulatory agency activities and programs including diagnostic evaluations, performance indicators, and reliability assessment studies. Finally, these lessons learned and findings

have been applied where appropriate, by the nuclear industry (participating plants), by other U.S. federal government agencies such as the U. S. Department of Energy (DOE), and by international agencies such as the United Kingdom Health and Safety Commission and the Swedish Nuclear Inspectorate, due to their interest in improving safety performance through organizational change.

Since the lessons learned presented in this paper often go beyond findings and conclusions presented in individual published reports on the research, a list of the latter publications is presented at the end of the paper without attribution to specific lessons learned. During the period leading up to the end of 1991, several technical papers emerging from the research were also presented to U.S. and international professional organizations.

3. METHODOLOGY

Lessons learned information was gathered from the research teams and individuals using a question and answer format. The following five questions were submitted to each team and individual.

[1] What organizational factors appear to influence plant safety performance in some systematic way?

[2] In order to fully understand plant safety performance and the factors influencing that performance, should organizational factors research focus at the plant level, or should it extend beyond the plant level to the parent company, rate setting commissions, or regulatory agencies?

[3] How important is having direct access to plants for doing organizational factors research?

[4] What lessons have been learned to date as the result of doing organizational factors research in a nuclear regulatory setting?

[5] What other organizational research topics and issues should be pursued in the future to build on lessons leaned to date, that you believe are important to plant safety and efficiency?

Respondents were asked to consider: (1) quantitative and qualitative analyses they had performed as part of their research. (2) serendipitous learning they experienced interacting with the plants and the regulatory agency while doing the research, and (3) perspectives they brought to the research from their experience doing similar work in other industries and environments.

Responses from the 15 teams and individuals were analyzed for content and frequency of response. Identical responses on individual issues provided by half more than half of the respondents were considered primary lessons learned. Identical responses on individual issues provided by less than half of the respondents are considered secondary lessons learned.

4. LESSONS LEARNED

Primary and secondary lessons learned, as represented by responses to the five questions are presented below.

[1] What organizational factors appear to influence plant safety performance, and how might this knowledge assist regulators?

Respondents concluded that there is no unitary organizational factor for explaining plant safety performance. Rather clusters of factors (profiles) made up of the primary factors, supplemented by situtationally determined combinations of secondary factors, best explain performance.
Respondents also concluded that an extensive overlap may exist between organizational factors which influence public safety, those which influence industrial safety, and those that influence productivity and efficiency.

4.1 Primary Factors

Four organizational factors were identified as influencing plant safety performance in a generalizable way. They are presented in descending order of priority.

- Communication (commonly understood organizational goals across and between management and worker personnel, and the means to achieve those goals)
- Organizational Learning (internalized mechanisms for achieving short and long term organizational change with minimal disruption)
- Organizational Focus (management [significant other] attention and oversight)
- External Factors (parent corporation, parent utility, regulating bodies)

4.2 Secondary Factors

Nine additional organizational factors were identified as influencing plant safety in more situationally determined ways. They are presented in descending order of priority.

- Technical Ability of Managers
- Resource Allocation by the Plant
- Perceived Comment (or managers by workers)
- Coordination of Resources (cost to benefit)
- Organizational Structure (within context of a machine bureaucracy)
- Management Stability (rate of changeover)
- Incentive Programs
- Standardization of Work
- Formal Decisionmaking

4.3 Knowledge to Assist Regulators

Respondents cited the following activities as potentially benefiting from the findings and products of organizational factors research. They are presented in descending order of priority.

- Data and methods for regulatory agency diagnostic evaluations
- Guidelines for plant self assessment
- Data and methods for HRA in PRA
- Guidelines for regulatory agency examiners
- Guidance to regulatory agency and industry senior management
- Data and methods for regulatory agency SALP assessments
- Basis for educating the engineering community on behavioral aspects of plant performance

[2] In order to fully understand plant safety performance and the factors influencing that performance, should organizational factors research focus at the plant level, or should it extend beyond the plant level to the parent company, rate setting commissions, regulatory agencies?

Based on current experience conducting organizational factors research in a nuclear regulatory setting, all of the 15 respondents recommended that the future research consider factors (entities) beyond the plant level in order to achieve more complete and accurate assessments of plant safety performance. The majority of respondents recommended that future research consider these external factors immediately. A minority recommend that the research be allowed to mature further before expanding its scope to external factors.

Both groups recommend the following factors (entities) be included, now or in the future, in a descending order of priority.

- Parent corporation
- Parent utility
- Public utility commission
- Nuclear Regulatory Commission

- Local government agencies

[3] How important is having direct access to plants for doing organizational factors research?

Based on current experience conducting organizational factors research in a nuclear regulatory setting, all of the 15 respondents consider plant access as critical to the success of their research. Organizational Factors research, unlike individual and small group centered research, cannot be conducted in contrived or laboratory settings. The organization must be studied in its natural environment, a plant setting. Regarding plant access, the following experiences are reported. They are not presented in a priority order.

- The plant personnel for the most part cooperate if they believed the research not threatening to them.
- If left to their own devices, researchers felt they could gain access without a lot of problems.
- Poor performing plants should be included in the research.
- The majority of the respondents considered the regulatory agency to be the main obstacle to gaining access to the plants, that is, placing certain plants off limits, involving too many regulatory entities in the process.
- Involvement of industry in the research to be very important. The majority also felt that the regulatory agency is the prime hinderance in achieving this goal.

[4] What lessons have been learned to date as the result of doing organizational factors research in a nuclear regulatory setting?

Responses to this question focused on respondent perceptions of the regulatory agency and the industry. They are presented in their order of priority ranging from 12 out of 15 responses down to 1 out of 15 responses.

- The regulatory agency has been a stumbling block for achieving a common understanding of the research by itself and industry, and in the latter's understanding of how it can be useful to them in achieving plant safety.
- The industry is suspicious, but wants to cooperate with the regulatory agency in this research, however, its cooperation depends on whether or not it understands how the research results can be useful to it.

- There is a general lack of appreciation within the regulatory agency over the scientific and regulatory goals of this research.

- The wide philosophical gap between engineers and behavioral scientists does not seem to be closing very fast.

- The timeframe for conducting the research is very extended, especially in instances where plant participation is required. This involves coordination with the regulatory agency and plants in setting up working agreements, and getting regulatory agency approvals.

- While the research is well organized and focused, it needs more long term and predictable support from higher level regulatory agency management. There is continuing uncertainty whether or not the regulatory agency will continue the research.

- Research is hindered by a lack of teamwork, mutual support, and understanding among units within the regulatory agency.

- The earlier that industry is brought into specific research projects the more it will support their goals and objectives.

- While a wide array of plant performance data are available, documentation of data is often inadequate, and may consist of idiosyncratic knowledge known only by an individual.

- The regulatory agency research staff had been very supportive making clear specific and general goals of the research.

- Research has attracted an exceedingly capable group of researchers. This cadre provides a very rich and rewarding opportunity to learn from one another.

- Success is failure. The better the research on the impact of organizational factors (success), the more likely the industry will put pressure on the regulatory agency to cut the funding for future research (failure).

- The farsighted approach the regulatory agency has taken to this work potentially enhances the chances of its success.

- Regulatory agency contract administration is a severe hinderance in achieving milestones in a timely manner.

- All regulatory agency research need not lead to regulation.

- The impacts of the research will take years to observe because of the required changes in management attitudes.

The following suggestions were made for dealing with some of the above perceptions. They are presented in order of priority.

- The regulatory agency should clearly state to industry how it intends to use the results of organizational factors research.
- The regulatory agency should coordinate/involve industry and its representatives in all aspects of the research.
- "One-on-One" workshops should be held between engineers and behavioral scientists to overcome philosophical gaps in their approaches to plant safety performance assessment.
- The regulatory agency should learn before it moves to regulation.

[5] <u>What organizational research topics and issues should be pursued in the future to build on the lessons leaned to date, and which you believe are important to plant safety and efficiency?</u>

Respondents generally supported the scope and direction of the current organizational factors research activity. In addition to their responses to other questions which can be used to improve the activity, respondents offered the following additional suggestions for improving the scientific credibility of the activity while at the same time enhancing the usefulness of its findings and products to the regulatory agency and industry. Comments and recommendations are not presented in priority order.

- A better operational definition of plant safety should be developed.
- Organizational groups (Sections Departments, Functions) larger than control room crews, but smaller that the total organization, should be studied.
- External plant influences should be studied, as well as the causal aspects of plant efficiency and productivity.
- Research should focus more closely on the technology transfer of products to industry and regulatory agency users.
- Non- or negative results should be reported to the scientific and user communities.

- Efforts should be made to minimize overlaps in the research and to bring closure to the results that have been achieved to date.
- An integration report should be prepared, among other things, as a means of defining future research.
- A study should be done to assess the impacts of Diagnostic Evaluations on safety.
- A study should be done to assess the impacts of an aging work force on safety.
- A study should focus on poor performing plants to establish a poor performing plant profile.
- Research should attempt to identify factors that allow good plants to remain good plants. Why do good plants stay good?
- Quantitative and qualitative validations of performance indicators should be continued with "new" post 1987-88 data.
- A resident inspector organization and management training curriculum should be developed from the results of research conducted to date.
- A study should be done to examine similarities and differences among organizational factors bearing on industrial and public safety.
- Research should focus on the technology transfer of current results to date, to industry and regulatory agency users.
- The activity should encourage and find new ways for engineers and behavioral scientists to work together to solve Organizational Factors issues of concern to the industry and the regulatory agency.
- An in-depth study should be done on similarities and differences between industry and the regulatory agency in the area of organizational factors and safety.
- Data from programs involving root cause analyses and effective spare parts policy should be examined for use in developing leading indicators of organizational performance.
- Focus of the activity should be away from PRA and toward support to licensing and diagnostic evaluation programs.

- An organizational factors training course should be developed from results to date, for general use in supporting the regulatory process.

5. CONCLUSIONS

Lessons learned to date from the research suggest that:

[1] No unitary organizational factor will explain plant safety performance, however, collectively four primary organizational factors appear to explain that performance in a systematic if general way. These primary factors include communication, organizational learning, management [or significant other] attention, and the external environment. Several other secondary and tertiary factors were also identified which, individually and in combination, appear to affect plant safety performance in more situationally determined ways.

[2] Technical knowledge gained from the research suggests that (a) a sociotechnical system combining properties of a machine bureaucracy (standardized work, direct supervision, vertical communication) with emergent processes (e.g, organizational learning), is a reasonable descriptor of nuclear power plant organizational functioning during normal operations, (b) research should extend beyond the plant level, (c) data from currently mandated regulatory agency reporting systems are not adequate for plant organization and management assessments, and (d) industry direct participation in the research is crucial for its success.

[3] The majority of respondents recommended moving beyond the plant to better account for overall variations in plant safety performance. Most frequently mentioned beyond plant entities are the (a) parent corporation, (b) parent utility, and (c) public utility commission.

[4] All respondents considered plant access critical to the success of the research. The majority of the respondents consider the regulatory agency itself to be the main obstacle to gaining access to the plants, that is, placing certain plants off limits, involving too many regulatory agency entities in the process, and a less than enthusiastic attitude of middle level management toward the research.

[5] Respondents presented 16 lessons learned from actually doing research in a regulatory environment where an adversarial relationship is perceived to exist between the regulator and the industry regulated. While a number of positive lessons learned were cited, the three most frequently mentioned lessons learned were of a critical nature which induce (a) industry suspicion of regulatory agency motives for doing the research, and (b) lack of appreciation on the part of the regulatory agency concerning the differences between the scientific and regulatory goals of this research given the regulatory agency's regulatory and enforcement missions.

[6] Respondents generally support the scope and direction of the organizational factors research activity, however, they offered at least 20 suggestions for improving its value to the agency and industry. Included among the more frequently mentioned are a need for (a) more explicit project/activity integration, (b) more explicit ties between anticipated products and specific agency and industry applications, and (c) studies identifying common organizational factors influencing public and industrial safety, and productivity and efficiency.

A more general conclusion based on the material provided for this report is that organizational factors research can be conducted in a regulatory setting and produce useful results. Technologies pioneered in other academic, commercial, and military settings can be adopted for use in a nuclear regulatory setting. The future success of this effort depends upon the cooperation of regulators, contractors, and the nuclear industry. Each in its own way can be expected to be a beneficiaries of the results. By regulators for moving beyond educated speculation to assessments of plant safety performance that are not only objective but instructive to both the regulators and the plant. By the licensees for self improvement. By the researchers, especially the 12 universities currently involved in the work, to collate and expand on the findings to the benefit of commercial, public, and military operators of complex high reliability socio-technical systems.

6. STATEMENT OF APPRECIATION

The author wishes to thank the following researchers for providing written responses to the five lessons learned questions as individuals or as part or a response team:

Dr. James Thurber, American University
Dr. Richard Osborn, Wayne State University
Dr. Frank Landy, Pennsylvania State University
Dr. Richard Jacobs, Pennsylvania State University
Dr. John Mathieu, Pennsylvania State University
Dr. Sonja Haber, Brookhaven National Laboratory
Dr. Mary Nichols, University of Minnesota
Dr. Alfred Marcus, University of Minnesota
Dr. Joseph Montgonery, Pacific Northwest Laboratories
Dr. George Apostolakis, University of California at Los Angeles
Dr. Jya Syin Wu, University of California at Los Angeles
Dr. David Okrent, University of California at Los Angeles
Dr. Nathan Siu, Massachusetts Institute of Technology
Dr. Erasmia Lois, United States Nuclear Regulatory Commission, Office of Nuclear Regulatory Research
Mr. Carl Johnson, United States Nuclear Regulatory Commission, Office of Nuclear Regulatory Research

Mr. Joel Kramer, United States Nuclear Regulatory Commission, Office of Nuclear Regulatory Research
Dr. Vojin Joksimovich, Accident Prevention Group
Dr. Douglas Orvis, Accident Prevention Group
Dr. Susan Van Hemel, Star Mountain, Inc.
Dr. Edward Connelly, Concord Associates, Inc.
Mr. John Wreathall, Science Application International Corporation
Dr. Mohammed Modarres, University of Maryland
Dr. Ali Mosleh, University of Maryland

7. SUGGESTED READINGS

[1] RYAN, T. G., "Organizational Factors Research Lessons Learned and Findings in a U. S. Nuclear Regulatory Setting." (Unpublished Manuscript), September 1991.

[2] U.S. NUCLEAR REGULATORY COMMISSION (NRC), "Organizational Analysis and Safety for Utilities with Nuclear Power Plants." Washington, DC: NUREG/CR-3215, August 1983.

[3] NRC, "Objective Indicators of Organizational Performance of Nuclear Power Plants." Washington, DC: NUREG/CR-4378, January 1986.

[4] NRC, "Development of Programmatic Performance Indicators, Objective Indicators of Organizational Performance of Nuclear Power Plants," Washington, DC: NUREG/CR- 5241, August 1986.

[5] NRC, "The Development and Evaluation of Programmatic Performance Indicators Associated with Maintenance at Nuclear Power Plants." Washington, DC: NUREG/CR-5436, (3 vols.), May 1990.

[6] NRC, "Organization and Safety in Nuclear Power Plants." Washington, DC: NUREG/CR- 5437, May 1990.'

[7] NRC, "Non-Nuclear Industry Based Performance Indicators for Nuclear Power Plants." Washington, DC: NUREG/CR-5568, July 1990.

[8] Battelle Pacific Northwest Laboratories (PNL), "Team Interacting Skills Evaluation Criteria for Nuclear Power Plant Control Room Crews." Richland, Washington: Technical Report No: 7250, October 1990.

[9] U.S. NUCLEAR REGULATORY COMMISSION (NRC), "Organizational Factors Research Progress Report." Washington, DC: Report to the Commission No. SECY-90-349, October 1990.

[10] NRC, "Collecting Organizational Factors Data and Industry Interest." Washington, DC: Report to the Commission No. SECY-91-105, April 1991.