Practicing Nuclear Safety Management

Learning from Safety Culture Failures: Training Nuclear Professionals to Manage in a Complex Environment

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This article describes a systems approach to developing safety management training simulators for nuclear professionals. Management "flight simulators" are increasingly being used to provide realistic, low-anxiety platforms for individuals to develop and practice essential skills. The approach is based on our extensive experience in nuclear management consulting and in applying business simulation to nuclear plant performance and asset management. It also proposes a unique collaborative process to bring to bear expertise across the industry in order to optimize and validate training tools.

Executive Summary

In the last fifteen years the U.S. nuclear industry has emerged from the variability and risks of a startup technology to the consistency and value creator of a blue chip portfolio. The industry has consolidated and a number of large, highly competent nuclear enterprises have come to dominate the ownership and operation of nuclear generating facilities. Now the industry is poised on the cusp of a "nuclear renaissance" and, for the first time in decades, will begin to construct new plants. A foundation of the nuclear renaissance has been a robust safety culture as the linchpin of the human component of nuclear safety. Yet, we continue to see in the nuclear industry instances of people acting contrary to the espoused belief system, and contrary to prior lessons learned. What causes these disconnects between safety beliefs and actions and what can be done about them?

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We believe safety management can be trained and practiced in a more robust and meaningful manner through the use of "management flight simulators". Such tools will allow nuclear professionals to develop and practice safety management skills under conditions that replicate the complexity and competing pressures of their environment.

A nuclear safety management simulator provides a realistic representation of nuclear plant performance, incorporating traditional operating and cost factors with organizational resource variables such as safety culture and employee trust. In the simulation, players make key decisions such as resource allocation and managing problem resolution, under competing priorities for schedule, cost and operations, and must maintain awareness of latent challenges such as complacency.

We plan to demonstrate the value of a nuclear safety management simulator through a collaborative approach with nuclear industry professionals. We have invested in the research and development of a prototype simulator (NuclearSafetySim), and now seek the cooperation of individuals and organizations to validate and refine this tool through a web-based process.

1. Introduction

In the last fifteen years the U.S. nuclear industry has emerged from the variability and risks of a startup technology to the consistency and value creator of a blue chip portfolio. The industry has consolidated and a number of large, highly competent nuclear enterprises have come to dominate the ownership and operation of nuclear generating facilities.[1] Now the industry is poised on the cusp of a "nuclear renaissance" and for the first time in decades, will begin to construct new plants. Both the success of current plants and the commitment to new plants raises the stakes for the industry to sustain very high standards of safety. A foundation of the nuclear renaissance has been a robust safety culture as the linchpin of the human component of nuclear safety. Safety being the "first and overriding priority" is the desired "state" of every nuclear organization and the "right stuff" of every nuclear professional. Yet, we continue to see in the nuclear industry, and other highly complex, technical industries, instances of people acting contrary to the espoused belief system, sometimes with safety significant consequences. What causes these disconnects between safety beliefs and actions and what can be done about them?

We believe the overall safety management process challenges safety culture in two ways. First, safety management requires balancing safety and other legitimate business goals, in an environment where there are few bright lines defining what is adequately safe, and where there are significant incentives and penalties associated with both types of goals. As a practical matter, "Safety culture is fragile…..a balance of people, problems and pressures."[2]

Second, safety culture in practice is "situational", and is continually being re-interpreted based on people's actual behaviors and decisions in the safety management process. Safety culture beliefs can be reinforced or challenged through the perception of each action (or inaction), yielding an impact on culture that can be immediate or incubate gradually over time. Absent a safety culture "meter" to provide indication of these changes and trends, organizations often only discover a significant deterioration in safety culture after the fact.[3]

Because safety culture is relatively intangible, it poses issues that regulators hesitate to address and organizations struggle to overcome. Existing remedial actions and methods for safety culture training emphasize reiterating values and priorities and performing surveys. Under these approaches it is hard to avoid the trap that beliefs may be definitive but decisions and actions often are much more nuanced. Surveys show a snapshot of safety culture at a point in time but do not deal with the dynamic nature of safety culture or illuminate how nuclear professionals actually manage.

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[1] "Nuclear Enterprise, Managing the Nuclear Generation Business in the 21st Century", R. Cudlin and L. Conner, Powershift LLC, January 2002; "Capturing Stranded Value in Nuclear Plant Assets", R. L. Cudlin and R. G. Schoenberger, The Electricity Journal, vol. 9, no. 5 (June 1996).

[2] Reactor Operations and Safety Course Outline, MIT Nuclear Engineering Dept, Andrew Kadak, Fall 2005

[3] Diane Vaughan's provocative analysis of the space shuttle Challenger disaster in The Challenger Launch Decision, Risky Technology, Culture and Deviance at NASA, The University of Chicago Press, 1966, argues that "the incremental expansion of normative boundaries: how small changes - new behaviors that were slight deviations from the normal course of events - gradually become the norm, providing a basis for accepting additional deviance. "[at page 409], and "the case affirms the important effects of production pressure on decision making but shows these effects to be much more subtle than previously surmised." [at p 407].

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2. Balancing Competing Priorities

There has been increasing awareness of the essential importance of safety culture to safety in complex, high risk, tightly coupled[4] enterprises such as nuclear generation and the U.S. manned space program. The human and organizational elements of safety culture represent barriers to risks as important as the defense in depth provided by hardware systems."[5] In addition there is also recognition that nuclear safety management and safety culture are highly interdependent.[6]

At another time, management malfeasance could be blamed when an organization saw safety as just one part of a deliberate calculus of business risk.

> "that management, using rigorous top-down budgets, was dedicated to a decade-long strategy with predictable high earnings from competitive positioning but with high risk of nuclear operational problems."[7]

The realization that safety needed to be institutionalized in a fundamental manner has been reinforced by serious accidents in other industries, including the Challenger and Columbia space shuttle accidents and the BP oil refineries. Professor Carroll of MIT, speaking with the benefit of his immersion in the problems at the Millstone nuclear plant, observed that,

> "Managers as well as workers are faced with conflicting demands and higher workload in the new industrial environment of downsizing and continual improvement....In their efforts to enhance performance and use resources efficiently, the nuclear power industry along with many other industries has turned to the improvement of 'culture'."[8]

In the last ten years the elements of nuclear safety culture have been fairly well fleshed out and awareness of its importance raised in all nuclear operating organizations. The NRC undertook a comprehensive regulatory policy review of safety culture. Nuclear industry

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[4] Perrow, Charles. Normal Accidents: Living with High-Risk Technologies. Princeton University Press, 1999.

[5] 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'. "Beyond Normal Accidents and High Reliability Organizations: The Need for an Alternative Approach to Safety in Complex Systems, Karen Marais, Nicolas Dulac, and Nancy Leveson, MIT, March 2004, at p.7

[6] Safety Culture (& ISM), Peter S. Winokur, Defense Nuclear Facilities Safety Board, November 28, 2007 (Slide Presentation)

[7] "The Strategic Destruction of Northeast Utilities", Paul W. MacAvoy and Jean W. Rosenthal, Yale School of Management, April 2001, at p.148. In some industries the choice is stark: "It's a Hobson's choice…of their safety or their jobs." New York Times, January 10, 2006, Endemic Problem of Safety in Coal Mining.

[8] Safety Culture as an Ongoing Process: Culture Surveys as Opportunities for Inquiry and Change, John S. Carroll, MIT Sloan School of Management, March 2002

groups supported major initiatives and the consolidation within the industry helped distill successful cultures and install them widely across operating plants.

The increasing attention and understanding of safety culture has raised consciousness of safety culture and contributed to increased knowledge and theories, but there are also indications that safety culture will require a high level of diligence. In the U.S. space program, the Challenger accident in 1986 led to a long shutdown of manned flights, numerous studies and NASA improvement programs. Yet seventeen years later the Columbia accident demonstrated some of the same issues persisted. Similarly in the nuclear industry, following the intense focus on safety culture at Millstone in (1996), safety culture issues arose at Davis Besse [2002], and there have been further occurrences, most notably at PSEG [2004] and Palo Verde [2007], and in Japan's nuclear program. Just in the last several months the failure to perform fire safety watch rounds at San Onofre revisited many of the same issues that were the subject of prior lessons learned.

So today nuclear organizations understand and subscribe to safety culture, realize that safety culture is on the critical path to business success, and have observed or experienced the consequences of failures of safety culture. Yet there are still problems. Why?

Let's start with the definition of safety culture as it is currently used within the nuclear industry. There are a number of definitions of safety culture. One by the IAEA is:

> "The assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance."

Definitions of safety culture such as the IAEA's emphasize the socio-anthropologic and socio-psychological aspects; that culture is intrinsic to the group of people, is enduring and to some degree, immutable. Safety climate is a related term used to describe individual's "perceptions" about the current state of safety culture. As such safety climate is more transitory.[9]

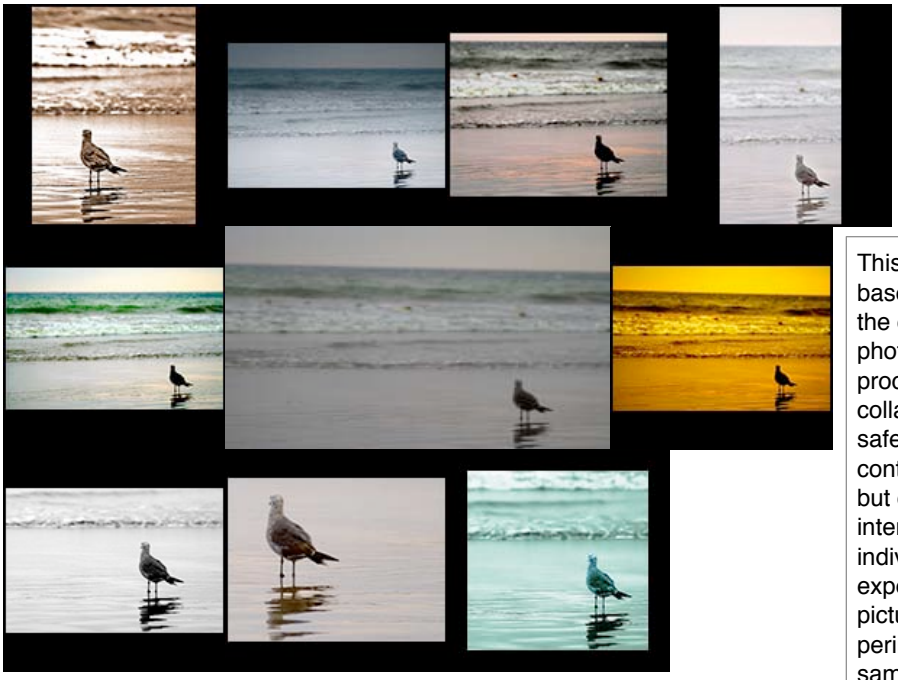
As safety culture theorists have pointed out, there are potential problems with this type of definition.

> "Many definitions of organizational safety culture tend to focus on the way people think or behave. However, most research investigating this culture construct has tended to focus solely on the way people think (i.e. their values, beliefs, attitudes, perceptions) about various aspects of safety, via safety climate measures, which have tended to be used as surrogate measures of safety culture. Issues related to situational constraints and peoples actual

[9] Inevitably when the topic of safety culture arises, the distinction between safety culture and safety climate also may be raised. There have been many and various definitions of safety culture and climate, and as many ways to distinguish the two concepts. "A Synthesis of Safety Culture and Safety Climate Research", Wiegmann et al, University of Illinois Aviation Research Lab, Technical Report ARL-02-3/FAA-02-2, June 2002 is a reasonable survey of these formulations. A principal distinction is where safety culture is relatively enduring and resistant to change, safety climate is more situational and changeable. On balance I must admit to a feeling that the differentiation is not extremely important for our purposes, since we are going to focus on the practical, everyday "sense" of safety within an organization as it may influence people's actions and decisions. In this vein I find one formulation of safety climate to be useful: "Safety climate can be viewed as a temporal state measure of culture, which is reflected in the shared perceptions of the organization at a discrete point in time." [at p. 9]

behavior have tended to be ignored."[10]

This raises questions, such as: How meaningful is safety culture absent its application and interpretation in specific situations and conditions? For example, at Millstone, Northeast Utilities evolved a definition of safety conscious work environment that stated "safety and quality are valued above cost and schedule"[11]. Without doubt this is a proper hierarchy, but just how useful is such a black letter rule? How many decisions do nuclear personnel make where the issue is simply safety or schedule or safety or cost? Isn't reality almost always much more nuanced, where safety and cost and schedule must be balanced, and all goals accommodated to some extent?



This collage of images is based on interpretations of the center image by other photographers using digital processing techniques. The collage is a metaphor for safety culture; the underlying content starts out the same, but continually gets re-interpreted based on individual perceptions and experiences. Are the pictures around the perimeter essentially the same as the original image, or significantly different?

This inherent overlap of goals and constraints has come to be recognized in studies across various organizations and industries. The independent safety panel investigating the BP oil refinery accidents observed:

> "Additionally, commercial considerations, including cost control and production, play a role in defining the safety culture of an organization. All organizations that produce goods and services not only face limitations on resources, including money, but also must effectively manage the tension that exists between the operational demands relating to production and

[10] Towards a Model of Safety Culture, M. D. Cooper Ph.D, *Safety Science* (2000): Vol 36, pp 111-136.

[11] Driving Organizational Change in the Midst of Crisis, John Carroll and Sachi Hatakenaka, MIT Sloan Management Review, Spring 2001 at p. 71.

> those relating to safety."[12]

In a broadly-based academic study of complex organizational systems, it was found that:

> "Safety goals often do not coincide with performance goals (unless the sole or primary purpose of the system is to maintain safety) and in fact often they conflict. In addition, while organizations often verbalize consensus about safety goals (e.g., "safety is our number one priority"), performance and decision making often departs from these public pronouncements."[13]

Returning to Professor Carroll's work with the Millstone plant, he describes the results of a safety culture project carried out within the Engineering organization. Team interviews were done with individuals and groups from the department.

> "Despite the overall conclusion that the safety culture is healthy, the team concluded that there are vulnerabilities because safety is understood narrowly and inconsistently....The interviews brought up issues regarding how difficult it is to manage with both schedule and safety issues, that management stress on safety depends on particular problems and situations….."[14]

"A further complication is that individual employee goals may conflict with one or more of the organization's goals. Beliefs about the requirements for career advancement, for example, may lead employees to behave in ways that run counter to the organization's interests or to safety goals." [15]

Recognizing these real world considerations, I believe safety culture is best understood as situational. By situational, I mean every decision, action, and communication within the organization has the potential to "interpret" safety culture. Certain actions can help reinforce desired safety culture beliefs. Others may erode those beliefs. Safety culture might be thought of as scaffolding (of values and beliefs) upon which additional interpretative structure is continually added through this process.

Not only does safety culture get redefined by its situational context, it appears that it must continually adapt to business environment constraints and pressures. Sometimes the adaptation is positive, sometimes it is in the direction of deviance. Ironically, deviations in safety culture may be inadvertent, where people are not aware of how their actions "feedback" to impact culture, and or become "normalized" through an organization's

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[12] The Report of the BP U.S. Refineries Independent Safety Review Panel, January 2007, p. 24. The report goes on to quote from James Reason, "Achieving a Safe Culture: Theory and Practice," Work & Stress, Vol. 12, No. 3 (1998), p. 301, " It is clear from in-depth accident analyses that some of the most powerful pushes towards local [culture] traps come from an unsatisfactory resolution of the inevitable conflict that exists (at least in the short-term) between the goals of safety and production. The cultural accommodation between the pursuit of these goals must achieve a delicate balance."

[13] Beyond Normal Accidents and High Reliability Organizations: The Need for an Alternative Approach to Safety in Complex Systems, Karen Marais, Nicolas Dulac, and Nancy Leveson, MIT, March 2004, at pgs 5,6

[14] Safety Culture as an Ongoing Process: Culture Surveys as Opportunities for Inquiry and Change, John S. Carroll, MIT Sloan School of Management, p.18.

[15] Ibid at p.7

ongoing recalculation of safety risks.[16] Further, there may be a lack of a consistent mental model across the organization of the safety management system, hindering shared perceptions and group learning.

Thus safety culture failures may best be thought of as outcomes where people are not able to appropriately exercise the many levers that are needed in safety management. Levers such as providing and allocating resources, building trust, assuring adequate safety infrastructure including procedures, managing backlogs, balancing short and longer term needs, and plant operational decisions.

Achieving the appropriate balance in decision making between competing goals is necessary for the viability of the enterprise.[17] Making the "right" decisions directly supports the goal of safety but also indirectly reinforces safety culture. For example, providing adequate resources for the Corrective Action Program (CAP) program (including the implementation of corrective actions) facilitates safety because specific identified issues are resolved in a timely manner and do not recur. In addition, the positive inference (safety really is important, management can be trusted, etc.) of the resource decision feeds back and reinforces safety culture.

I share the view of researchers at MIT that safety, and therefore safety culture, is inherently a "control problem" pertaining to the entire socio-technological system.[18] In this context control has a broad meaning including the actions of management; organizational characteristics such as policies and procedures; and the beliefs, values and behaviors of people. In other words, and perhaps most importantly, it means safety culture can be managed. Safety culture is simply a critical, albeit intangible, resource within the organization, one that can help create significant value or pose significant risk.

3. The Practice of Nuclear Safety Management

When safety culture is understood as a resource within a complex organizational system,

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[16] "Systems and organizations continually change as adaptations are made in response to local pressures and short-term productivity and cost goals. People adapt to their environment or they change their environment to better suit their purposes. A corollary of this propensity for systems and people to adapt over time is that safety defenses are likely to degenerate systematically through time, particularly when pressure toward cost-effectiveness and increased productivity is the dominant element in decision-making (Rasmussen 1997). Major accidents are often caused not merely by a coincidence of independent failures but instead reflect a systematic migration of the organizational behavior to the boundaries of safe behavior under pressure toward cost-effectiveness in an aggressive, competitive environment. Leveson cites both the Challenger and Columbia accidents as resulting from the gradual drift of organizational risk within NASA due to internal and external pressures. "Safety in Integrated Systems Health Engineering and Management (This paper is a draft paper for the NASA Ames Integrated System Health Engineering and Management Forum), Nancy Leveson, MIT, November 2005, at p.4.

[17] The recent incidents at San Onofre remind us that safety management involves balancing beyond just goals. Here deliberate misconduct in not performing fire watch rounds could have been the result of an emphasis on accountability trumping the desire for workers to self report errors. Letter E. Collins, U.S. Nuclear Regulatory Commission to Richard Rosenblum, Southern California Edison Company, January 11, 2008, attaching Confirmatory Order (at p. 5).

[18] Modeling, Analyzing, and Engineering NASA's Safety Culture, Phase 1 Final Report, September 2004 to February 2005, Nancy Leveson et al.

there are direct implications for the type of training that will best prepare personnel to play a productive role in building and sustaining the desired culture. The propensity across industries has been to respond to safety culture failures with interventions designed to restore the appropriate culture. These interventions tend to emphasize culture surveys, reiteration of values and motivational devices, such as posters. While there is nothing wrong about such approaches, it is fairly easy to see that they do little to directly improve the skills of personnel in managing safety culture on a day to day basis.

NASA Safety Posters

Surveys show a snapshot of safety culture at a point in time. To the extent they deal with the relation of safety culture to other legitimate organizational needs, the focus is on whether safety priorities are being observed - not why or how those priorities must be managed. In addition, surveys (at best) reflect what people think, not what they do or would do in a specific situation. Reinforcement of values can be of some benefit but mostly at a "maintenance level" designed to sustain awareness. What is lacking in these approaches is skill-based training designed to integrate of safety culture management with other management actions and priorities.

The most effective training, especially for managers, requires them to think (gather data, form hypotheses, reflect on experience) and do (make and implement decisions). It helps them "connect the dots" between their own actions (or inactions), the feedback effects of those actions on culture and other priorities, and whether outcomes, short and long term, are what they anticipate and desire. This type of training may be able to be accomplished by doing (on the job), over relatively long periods of time and constantly with the risk of costly failures and inconsistent skill development. I believe that a preferable, more efficient and effective approach is to employ management flight simulators.

The Logic of Failure

"Future environmentalists will heed Dietrich Dorner's "The Logic of Failure." Mr. Dorner is a cognitive psychologist who invited academic experts to manage the computer simulations of various environments. Most experts made things worse. Those managers who did well gathered information before acting, thought in terms of complex-systems interactions instead of simple linear cause and effect, reviewed their progress, looked for unanticipated consequences, and corrected course often. Those who did badly relied on a fixed theoretical approach, did not correct course and blamed others when things went wrong. Mr. Dorner concludes that our failure to manage complex systems such as the environment reflects bad habits of thought, over-reliance on theory and lazy procedures. His book is brief, cheerful and profound."

Wall Street Journal, October 22, 2005, p.10

4. System Dynamics and Management Flight Simulators

"Computer simulation is an imitation of selected properties of reality, usually for the purpose of getting answers or practicing and rehearsing problem-solving skills."[19] A management simulation game is a particular form of a simulation model, one where humans (players) interact with the model and make most or all significant decisions bearing on outcomes. Gaming-simulation turns passive recipients of information in a classroom into active participants."

A management flight simulator is an artificial environment within which to practice essential skills and functions; it is to a manager as an aircraft flight simulator is to a pilot.[20] At the heart of most management flight simulators is a technical discipline known as "system dynamics", a methodology developed by MIT Professor Jay Forrester in the 1950s. It relies on variables to represent "levels" (resources) and "flows" within a "system". Of great significance is the incorporation of "feedback" loops within the system that allow variables to interact with each other.

The insights offered by a systems approach have been recognized within the nuclear industry. "INPO started with a 1990s accountability model for the industry. It worked well in some respects, but did not take a systems view [emphasis added] of the organization,

[19] SimNavy – Phase 0 Building an Enterprise Model of the US Navy, Michael Zyda, John Hiles, Richard Rosenbaum, LCDR Kim Roddy, USN, LT Todd Gagnon, USN, & MAJ Mark Boyd, USA Naval Postgraduate School & Thinking Tools, Inc. Monterey, California

[20] For a discussion of the advent of management flight simulators see: The Management Flight Simulator, John H. Saunders, PhD,, Info Tech Talk, Spring 1998.

which was important at Davis Besse."[21] Such situations require a broader, and admittedly more complex, perspective of organizational failure.

I first encountered system dynamics in the form of Peter Senge's compelling book, "The Fifth Discipline", published in 1990. Senge focused on new disciplines of learning such as systems thinking, mental models, and team learning. He argues, persuasively, that "Business and other human endeavors are also systems...bound by invisible fabrics of interrelated actions, which often take years to fully play out their effects on each other."[22]

"System dynamics is a powerful basis on which to build a strategic architecture because it directly describes the 'physics' of the business [and organization] in a rigorous resource-based language. Moreover, SD has the capability to describe and analyse intangible assets explicitly..."[23] including safety culture and other organizational attributes.

Systems dynamic modeling is considered state of the art and has been used to construct models across many complex organizations such as NASA's manned space flight program, oil refinery management (Chevron), the U.S. Navy enterprise, and MBA program ethics training (University of Texas, McCombs School of Business). Within the nuclear industry system dynamics has been applied to the simulation of work processes to evaluate maintenance best practices.[24] Application to training of nuclear professionals in safety management is a logical and incremental step for this technology.

5. Nuclear Renaissance

Before concluding with a discussion of a proposed approach to safety management training, I wanted to touch on the current and future state of the nuclear industry.

As mentioned in the introduction, a renaissance in the nuclear industry is in progress, made possible in large measure by the vastly improved performance of existing plants. In addition, the consolidation within the U.S. industry:

> "...allowed bigger firms to acquire reactors on the cheap, and thus to achieve economies of scale and to capitalise on their experience. These nuclear specialists have been able to speed up the refueling process, keep shutdowns for maintenance to a minimum and so keep the reactors going more of the time. Last year the average nuclear reactor in America was in use

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[21] Safety Culture Public Meeting, November 29-30, 2005, Meeting Summary, Summary of INPO Initiatives.

[22] The Fifth Discipline, Peter Senge, Doubleday/Currency, 1990 at p.7.

[23] "Developing real business models to create value, Strategy simulations for planning and communication", Version 2.0, Richard Stevenson, Valculus Ltd , March 12, 2007, at p. 9.

[24] The Operational Risk Simulation Model (ORSIM): Use of ORSIM in Pilot Project Demonstration and Identification of Nuclear Power Plant Maintenance Best Practices, EPRI, Palo Alto, CA, 2006, 1011911, (Note: Section 2 of this report provides a useful introduction to systems thinking.).

90% of the time....All this has turned nuclear-power plants into virtual mints".[25]

"Utilities are also confident that they can build new reactors more quickly than before....All this should reduce the time required for construction to four years"[26]. This is all good news for the future prospects of the industry, but what are the implications for safety culture?

Current high performance levels of U.S. plants may actually increase the pressure on nuclear managers to sustain those levels. At the same time, good performance raises the risk of complacency regarding potential risks and challenges to safety culture. "Due to economic pressure to continually reduce outage durations, INPO anticipates that SOEs during refuelings will increase in frequency and severity."[27] I would also note that in addition to economic pressures, there is considerable peer competition within the industry to be best in breed by achieving ever increasingly longer runs, shorter outages, etc.

> All this has turned nuclear power plants into virtual mints...
>
> *The Economist*

With orders for new plants, nuclear construction organizations will need to establish and sustain robust safety cultures comparable to operating organizations. Yet most work will be contracted out to third parties and the history of organizational-based problems from construction of the first generation of plants is less than perfect.[28] Even more recently, the DOE has had to take action to address issues with Bechtel and its work at the Yucca Mountain waste repository.

All of this suggests that safety management will remain an area of intense focus and importance to the nuclear industry. Our focus is on how to bring state-of-the-art tools to assist nuclear professionals in these areas.

6. Our Research

My extensive experience in working with nuclear organizations that had encountered significant problems in consistently achieving safety performance goals, led me to conclude that the "practice" of safety management was something that could improve necessary

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[25] "Atomic Renaissance", The Economist Magazine, September 6, 2007. See also, New Reactors Across the Globe: A Nuclear Power Renaissance", The New York Times, January 16, 2007, "The industry, in short, is preparing for a new boom."

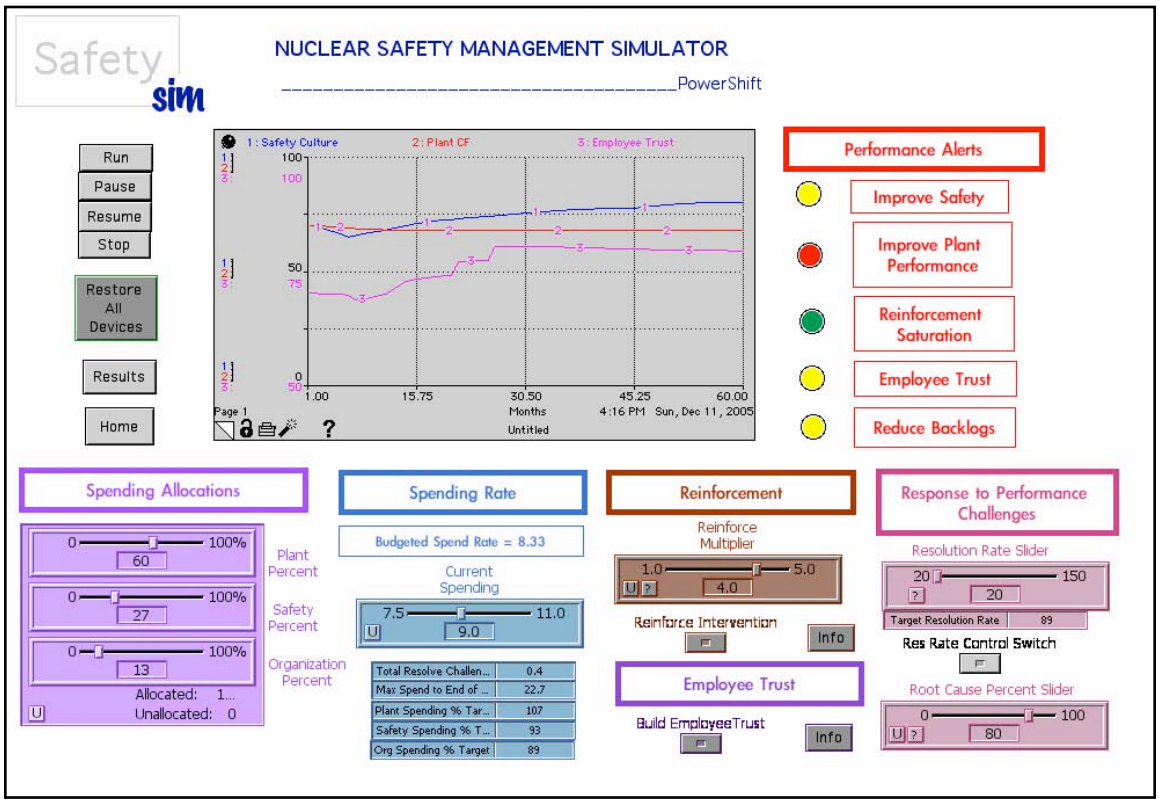
[26] "Atomic Renaissance", The Economist Magazine, September 6, 2007

[27] Comments submitted by David Collins on Proposed Generic Communication (RIS) Establishing and Maintaining a Safety Conscious Work Environment, November 11, 2004 and attaching a slide presentation by Collins:Ensuring Safe Cultures in High Hazard Ventures – An Integrative Approach (Draft Nov 04), p.24.

[28] "Organizations that contract out part of their functions have additional goal conflicts— the pressure to maintain supplier relationships is very great...: It is more more difficult to come forward with negative information when you are employed by a firm that could lose its relationship with a prime customer; you also lose the place you have made within that customer organization." Beyond Normal Accidents and High Reliability Organizations: The Need for an Alternative Approach to Safety in Complex Systems, Karen Marais, Nicolas Dulac, and Nancy Leveson, MIT, March 2004, at p.7

skills. I believed that a management flight simulator would provide a helpful and effective environment for nuclear professionals to enhance their safety management skills outside of the real world of their day-to-day jobs. As Edgar Schein has described it, an essential ingredient for learning to take place is a "safe environment" "Learning anxiety comes from being afraid to try something new for fear that it will be too difficult, or that we will look stupid in the attempt."[29]

Much of the state of the art for safety simulation is evolving in the context of the manned space program, in response to the loss of two of the space shuttles. MIT is working on models of NASA safety management as part of an integrated risk management analysis.



Based on my prior development work in nuclear plant business simulation, I believed, as do the researchers at MIT, that safety culture could be modeled based on system dynamics principles and simulations could be built that allowed nuclear personnel to train and practice making safety management decisions. Based on this approach I led a small team at PowerShift LLC in developing a beta version of NuclearSafetySim tools.

An image of its main user interface or "dashboard" is provided above.

NuclearSafetySim is a "management flight simulator" that provides a unique representation of nuclear plant performance, incorporating traditional operating and cost factors, with organizational "resource" variables such as safety culture and employee trust. In the

[29] Are Innovative Firms Bound to Die? An Interview with Edgar Shein, Business World, M. RAJSHEKHAR, Sept 15, 2003

simulated “game” experience, players make key decisions such as resource allocation and managing problem resolution, under competing priorities for schedule, cost and operations, and also must be aware of latent challenges such as complacency. Development was based on the iThink[30] simulation engine and analytical relationships for key model variables. Performance results can be compared against pre-defined goals and used to refine and share “mental models” for safety management.

The completed simulation is unique both in it’s representation of a nuclear safety management system and the framework of an interactive, training tool. Perhaps of most significance to representing complex socio-technical systems, in NuclearSafetySim the actions taken by players determine most aspects of the model response and contribute to a realistic environment of managing competing pressures to achieve results.

7. Benefits of Collaboration

We have opted for an approach that seeks the cooperation and collaboration of people within the nuclear industry. We think this is the path to the most robust and useful management flight simulator for nuclear safety management. In addition, we believe that the benefits of team learning, a fundamental principle of system dynamics, are great and can begin accruing in the collaborative process we are proposing. Bringing together a significant number of nuclear professionals in an interactive and collaborative environment should provide a multiplier on the benefit received by each individual and in the simulation tools.

A website has been established to support the collaborative effort:

nuclearsafetysim.com

We have developed NuclearSafetySim as “Version 1.0” with the intent to revisit all of its major components block by block through the collaborative process. Having a fully fleshed out simulation will be of benefit in avoiding a blank sheet of paper as a starting point, and the ability to look ahead to a fully composed simulation. At the end of the process we hope the NuclearSafetySim tools will be better and useful, that there will be a cadre of nuclear professionals with significant insight into this approach, and there will be a better opportunity for hands-on safety management training to be a core training objective for all nuclear organizations.

Conclusion

This paper is an attempt to both illuminate and motivate. The proposed approach offers the potential for significant benefits in terms of training efficacy and ultimately, nuclear safety. Importantly it looks to leverage and share the significant expertise within the industry, building tools that can help individuals and organizations improve and preserve critical skills. Join the process, be it as an observer, a contributor, an expert or a sponsor.

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[30] a product of isee Systems, iseesystems.com

