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Operators' Improvisation in Complex Technological Systems: The Last Resort to Averting an Assured Disaster

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Synopsis

When complex technological systems, such as nuclear power plants, move from routine to non-routine (normal to emergency) operation, the control operators need to dynamically match the system's new requirements. This mandates integrated and harmonious changes in information presentation, changes in performance requirements in part because of operators'inevitable involuntary transition to different levels of cognitive control, and reconfigurations of the operators'team (organizational) structure and communication.

In order to survive, a technological system must have the ability to respond to operational anomalies before any undesirable consequences, which the system seeks to avoid, can occur. That is, the control structure must run at a faster rate than the environment it seeks to control; or else, the system will lose control. However, a hierarchically structured team has only a limited control model of the system, which oversees. For instance, in the case of a power plant particularly during an emergency, the operators not only comply with (EOPs), they must also respond to the changing system's environment. To the extent that every possible deviation in this environment has not been foreseen by the 'hierarchy,'control is transferred to the work domain level – to operators – and due to (their) survival needs and instincts the system's control team inevitably embraces structural forms that fit the situational demands, often the more naturalistic form such as 'self-organizing.' Moreover, the hierarchical (team) structure becomes even more counter-productive when decisions need to be made by the whole team using the 'team mind.'
As task uncertainty increases in complex systems, (typical in "non-normal"or emergency situations), the number of exceptions to routine operations increases, overloading organizational hierarchy. In order to meet the new challenges, the organization must use another mechanism to sustain itself. Furthermore, the "normal function"of tightly coupled technological systems is to operate on the boundary to loss of control. That is, people are involved in a dynamic and continuous interaction with the failure and hazard (Rasmussen, 1989). Thus, "touching the boundary to loss of control is necessary (e.g., for dynamic "speed-accuracy"trade-offs)" (Rasmussen, Pejtersen, & Goodstein, 1994). This is a rapidly changing environment, and in order to survive it, the system should be able to respond in a safe and effective manner. Occasionally, it may require an improvised response from the operator(s), but it should certainly be coordinated and in concert with others' activities and stay within the boundaries or "space"of acceptable work performance (Rasmussen, 1989). Otherwise, it would be just noise in the control of the system and could lead to errors. It must also be able to flexibly reconfigure and synchronize all of its system elements to address the threatening issues.

The brining the four nuclear reactors at the Fukushima Daini plant to the cold shut down, after the Tōhoku earthquake, tsunami and station black out of March 11, 2011, was nothing short of a miracle. The heroic act of a dedicated group of human operators, who went out of their way and by encountering multiple sources of hazards and harms, taking personal risk, and by relaying on their ingenuity, teamwork, and dedication despite all odds, brought all four reactors to cold shutdown and consequently averted the second assured nuclear disaster in Fukushima prefecture with serious implications for travelling fallouts to Tokyo and need for its evacuation.

The Superintendent of the Fukushima Daini Nuclear Power Station, Mr. Naohiro Masuda, and his operators resorted to improvisation to save the day after experiencing station black out; and their improvised acts are too numerous to mention. Nevertheless, the most memorable noteworthy ones include, "flexibly applying EOPs" and "Temporary cable of 9 km length was laid by about 200 personnel within a day. Usually this size of cable laying requires 20 personnel and more than 1 month period."Their personal sacrifices and dedication of staying in the plant and continuing working in dire conditions, while not knowing whether their families survived the earthquake and tsunami, and working relentlessly to bring the four reactors to the cold shutdown state, are of epic proportion. These operators, who certainly are unsung heroes, deserve to also be considered as national heroes of Japan. Their problem solving behavior was the perfect examples for a successful knowledge-based level of cognitive control.

Fukushima Daini operators once more verified and exemplified the notion that at the time of a major accident at a complex, large scale technological systems, such as a nuclear power plant, human operators always constitute the society's both the first and last layer of defense. For the foreseeable future, despite increasing levels of computerization and automation, human operators will have to remain in charge of the day-to-day controlling and monitoring of these systems, since system designers cannot anticipate all possible scenarios of failure.

Country or International Agency

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