Resilience Engineering: Redefining the Culture of Safety and Risk Management

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The first impulse after tragic accidents in aviation, transportation, health care, or power generation is to label human error as the cause. Headlines continue to announce human error as if that explained how the accident occurred and how similar events could be prevented in the future. But research has consistently pointed to different result: Rather than focus on an individual or specific human decision or action, the data are found to point to organizational factors that set up the conditions for failure to occur—organizational accidents.

The question then becomes, what is the difference between organizations that can manage high hazard processes well and others that inadvertently create complexity and miss signals that risks are increasing. This research often focuses on the question of what is safety culture, what are indicators of poor safety culture, and what are the ways leadership signals a commitment to safety.

Line managers push back when they hear about these results: "Changing culture is difficult and slow"; "I am under increasing schedule and financial pressure"; "I can demonstrate continual improvements in many areas of my operation"; "I have decisions to make about how to invest limited resources in risky projects."

Managing risk proactively is difficult. When organizations are struggling to meet daily pressures, how can they tell the difference between inefficiencies and buffers against the unexpected? Resilience engineering is one new approach to provide tools for proactive safety management.

To provide some structure for this article, *HFES Bulletin* Features Editor Pam Savage-Knepshield posed a series of questions, which I answer below.

How do you define "resilience engineering," and why do you consider it an emerging discipline?

Around 2000, I noticed a shift in the language and concepts that safety researchers were using to discus how organizations succeed and fail. Many of the papers began to use words like *resilience* or *robustness* to describe organizations that were able to achieve ultra-high levels of safety despite high risks, difficult tasks, and constantly increasing pressures. Resilient organizations were proactive and adaptive, and this led to organizations that not only had high safety but also were able to respond effectively to many types of changes in today's highly pressured business and operational settings.

NASA in particular realized the need for proactive safety management processes in the aftermath of, first, the series of Mars exploration failures in 1999 and, then, the *Columbia* space shuttle accident in 2003. NASA experienced how pressure to be "faster, better, cheaper" led to management decisions that pushed the organization closer to the edge of the performance envelope without anyone's realizing how risk had increased.

The common thread in the work on proactive safety was the idea that *resilience* is a critical systems property when organizations are under pressure both to be highly productive and to achieve ultra-high levels of safety. Resilience refers to the art of managing the unexpected or how a team or organization becomes prepared to cope with surprises. Resilience comes from the Latin *resilire* –" to leap back," and denotes a system property characterized by the ability to recover from challenges or disrupting events. Resilience engineering assesses changes in the adaptive capacity of an organization as it confronts disruptions, change, and pressures.

Previously, organizations focused on improving their efficiency, productivity, and effectiveness—being "faster, better, cheaper," to use the slogans of NASA senior management. The data on organizational accidents revealed how this strategy was incomplete. As NASA had discovered, a fourth parameter was needed that focused on anticipating changes in risk without waiting for accident or near miss data to accumulate. I proposed at NASA's Design for Safety meeting in 2000 that a system's resilience in the face of disruptions could serve as that fourth parameter of high-performance organizations and that proactive safety management should help organizations achieve a dynamic balance across all four of these parameters.

Many tools already exist to model, measure, and improve the parameters of efficiency, productivity, and effectiveness. I went to my colleagues in safety engineering, organizational factors, and cognitive systems engineering and suggested that the time had come when we could develop tools for organizations to model, measure, and improve their resilience. With measures of resilience included, organizations would know how and when to rebalance safety against the continuing pressure to be faster, cheaper, and better. It turned out to be easy for people to recognize that most of the work on safety was pointing toward such a concept. The key event was an international symposium held in Sweden in late 2004. The result was consensus that this was a highly promising direction, and a book was soon published that capture some of the initial ideas about the importance of resilience.

What related fields of study does resilience engineering build upon, and what new concepts or principles does it introduce?

Resilience engineering builds on advances in modeling and measuring complex adaptive systems, the insights gathered from observations of high-reliability organizations, and the results from studies of how people adapt to make systems work despite complexity in cognitive systems engineering.

The first basic concept is the adaptive capacity of an organization as it confronts disruptions, change, and pressures. Measures of adaptive capacity can be used to assess how the system is both resilient in some ways and to some challenges and brittle in the face of other challenges.

Second, focusing on resilience changes how one analyzes incident data and how one interprets indicators of organizational culture. The issue is what are the diagnostic signals that reveal when the organization is edging closer to safety limits as it copes with faster, better, cheaper pressure *without the organization realizing it is operating more precariously*.

One of the key diagnostic signals is how people or groups in the organization make sacrifice judgments. Sacrifice judgments occur in particular situations when someone faces a trade-off in trying to decide if acute production-or efficiency-related goals should be temporarily relaxed—the sacrifice—in order to reduce risks of approaching too near safety boundaries.

Examples of sacrifice judgments include the decision about when to convert from laparoscopic surgery to an open procedure in surgery and in the decision about when to break off an approach to an airport during weather that increases the risks of wind shear in aviation. If people and managers in these situations are very reluctant to sacrifice production (e.g., arrival delays) to invest extra resources in reducing possible future risks, then the organization is acting much riskier than it really wants and knows. If peers and managers react negatively when someone makes a sacrifice decision, then the organization is more brittle than management realizes.

Another key diagnostic signal about an organization's resilience can be seen in how cross-checks work. How well can people in one role—especially if that role has less status or authority in the organization—cross-check people in other roles to detect early signs of a possible misassessment or erroneous plan? If cross-checks are weak or ineffective (e.g., because they are seen as unnecessary distractions), the organization is brittle.

What do you see as the relationship between *resilience* and *brittleness,* and why is it significant?

The opposite of resilience is *brittleness*, referring to systems that break down rapidly when boundary conditions or underlying assumptions are challenged by new events. In other words, examining a system's resilience means one studies how the system in question performs when it is pushed near boundaries of how it has been designed to operate. "Surprising" events are those that challenge the boundary conditions or a combination of events that push systems close to operational boundaries. Analyses of dramatic failures of complex systems, such as the *Columbia* space shuttle accident, have shown how these organizations missed signals that operations had become more brittle as production pressure eroded various buffers and resources that had provided resilience.

Resilience is a parameter of a system that captures how well that system can adapt to handle events that challenge the boundary conditions for its operation. Such challenge events do occur (a) because plans and procedures have fundamental limits, (b) because the environment changes, and (c) because the system itself adapts given changing pressures and expectations for performance. The capacity to respond to challenge events resides partly in the expertise, strategies, and tools that people use to prepare for and respond to specific classes of challenge.

But management also monitors for signs that indicate whether the organization has the adaptive capacity to handle challenge events and how to target investments to increase adaptive capacity despite omnipresent pressures for productivity. Can the organization recharge resilience when buffers are depleted, margins are precarious, processes become stiff, and squeezes become tighter?

Which types of systems and organizations can benefit from the application of resilience engineering principles?

We are seeing the concept of resilience being picked up by organizations in the transportation and oil industries, in health care, and in business. For example, the Institute of Medicine just released a report that concluded that hospital emergency departments are the brittle point in the national health care system.

What advice do you have for researchers interested in pursuing studies in resilience engineering?

The field is at that early stage of excitement when one can feel the possibility that new insights are just around the corner. I have been so pleased with how many younger researchers have resonated with the idea of resilience and how it has inspired them to look at organizations and processes with a new kind of conceptual lens. When they do this, interesting findings result and promising new directions emerge. I am looking forward to very fast developments in this field, and I expect to be surprised by the results that emerge.

What advice do you have for organizations interested in implementing resilience engineering in their system design efforts?

Middle managers feel squeezed in today's organizations under faster, better, cheaper pressure. Resilience engineering can help identify when those pressures are squeezing out the buffers and other sources of resilience that are needed for ultra-high-quality performance in a changing and surprising environment. Resilience engineering can help make safety organizations more effective partners with line managers as they pursue ultra-high levels of safety.

But resilience engineering is young, so we are looking for organizations that recognize they are becoming more brittle to join with us as early adopters and codevelopers of the pragmatic tools for engineering resilience into organizational performance.

Where should people go to find out more about resilience engineering?

The following references are helpful.

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