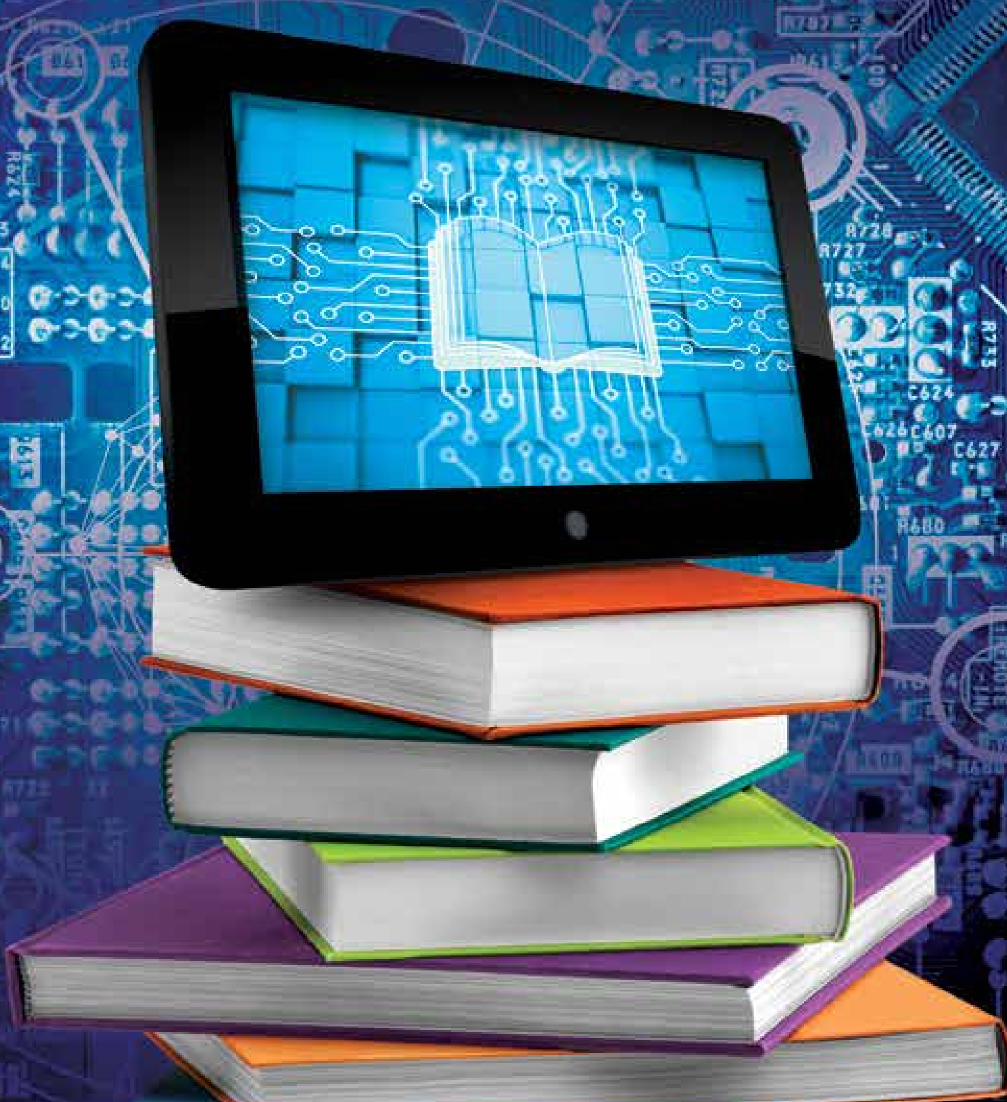
PROFESSIONAL READING LIST

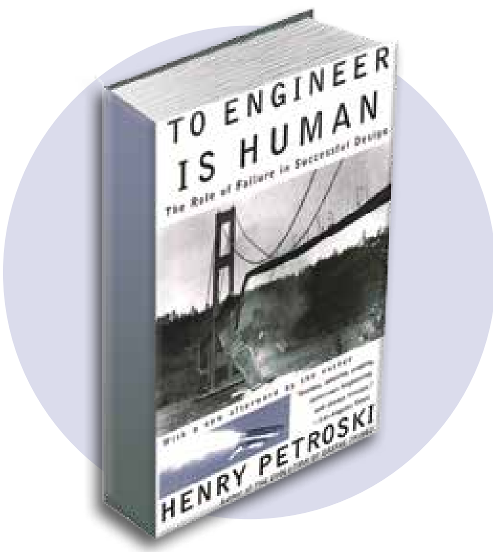
RECOMMENDED READING FOR AT&L PROFESSIONALS BY CAREER FIELD: TECHNICAL



Engineering, Life Cycle Logistics, Science and Technology Management, Test and Evaluation, Information Technology, Facilities Engineering

FOR KEY LEADERS

To Engineer Is Human: The Role of Failure in Successful Design



Author(s):
Henry Petroski

Publisher:
Vintage Books

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Hard/Softcover:
Softcover, 272 pages

Reviewed by:
Aileen Sedmak
Deputy Director for Systems Engineering Policy, Guidance, and Workforce, Office of the Deputy Assistant Secretary of Defense for Systems Engineering

Author Summary

This book has its origins in the basic question: What is engineering? It sets forth the premise that understanding failure is essential to understanding and achieving success in engineering. Fundamentally, engineering is figuring out how things work, solving problems, and finding practical uses and ways of doing things that have not been done before. Successful engineers properly anticipate how things can fail, and design accordingly. Case studies of past failures thus provide invaluable information for the design of future successes.

Conversely, designs based on the extrapolation of successful experience alone can lead to failure, because latent design features that were not important in earlier systems can become overlooked design flaws that dominate the behavior of more complex systems that evolve over time. This paradox is explored in *To Engineer Is Human* in the context of historical case studies, which provide hard data to test the hypotheses put forward. Among the historical data points are the repeated and recurrent failures of suspension bridges, which from the 1850s through the 1930s evolved from John Roebling's enormous successes—culminating in the Brooklyn Bridge—to structures that oscillated in the wind and, in the case of the Tacoma Narrows Bridge, twisted itself apart and collapsed in 1940. Lessons learned from these cases and others are generalized to apply across a broad spectrum of engineering structures and complex systems. They also help explain why failures continue to occur, even as technology advances.

—Summary by Henry Petroski

Review

Henry Petroski's 1982 classic is relevant today given the Department of Defense's challenge to develop and deliver highly effective and reliable defense systems that are increasingly integrated and complex. A natural result of this increased complexity is increased risk and probability of failure. However, efforts to eliminate all risk would impede the department's ability to provide the warfighter with the technological superiority to dominate the battlefield in an economical and timely manner. Instead, Petroski challenges us to understand and learn from our failures, which allows us to push the technical edge of our defense capabilities even further.

As an example, Petroski cites the case of Washington State's Tacoma Narrows Bridge, which shook apart in high winds just a few months after opening in 1940. The engineer, Leon Moisseiff, based the bridge design on the designs of several successful bridges of the time, but he did not consider the wind-related problems that had damaged other bridges. All structures have a natural resonance, and the bridge design did not account for this resonance. When the wind hit 42 miles per hour, it caused the motion that ultimately led to failure. As a result of this disaster, modern structural engineers now factor in wind flow. They use simulation programs to better understand and design for the natural resonance of bridges, buildings, and other structures.

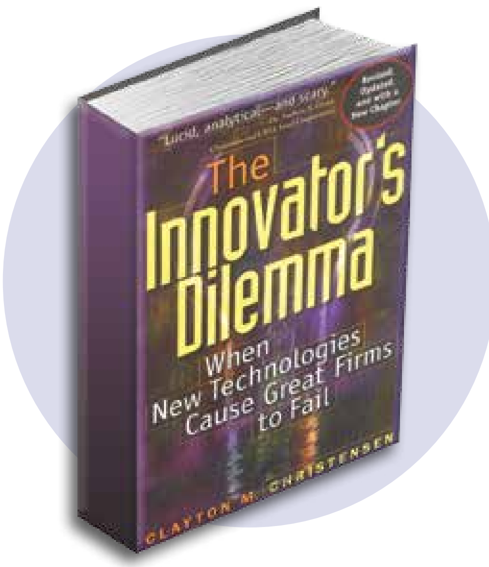
Sharing this and other classic examples of engineering failures—a 1979 DC-10 crash in Chicago, a 1981 Kansas City Hyatt Regency walkway collapse, and more—Petroski shows that a failure-proof design does not exist, that innovation involves risk, and that studying failures contributes more to advancing technology than copying successes. “One of the paradoxes of engineering is that successes don’t teach you very much. A successful bridge teaches you that that bridge works,” Petroski says. This success does not prove that the same bridge, built at a different location or made longer or taller, would also be successful. “It’s all theory until it’s completed,” Petroski explains. Yet engineering curricula often focus on successful designs and neglect unsuccessful ones, which, ironically, could lead to future failures.

Petroski stresses we need to understand how failures happened and incorporate this learning into the design process. Failure analyses influence the way engineers hypothesize, push the limits, and develop new systems and structures. Petroski says, “I believe that the concept of failure…is central to understanding engineering, for engineering design has as its first and foremost objective the obviation of failure. Thus the colossal failures that do occur are ultimately failures of design, but the lessons learned from these disasters can do more to advance engineering knowledge than all the successful machines and structures in the world.”

This brings Petroski to another point—that Moisseiff’s reliance on engineering successes and exclusion of engineering failures has a modern-day counterpart: computer simulation. “There is clearly no guarantee of success in designing new things on the basis of past successes alone, and this is why artificial intelligence, expert systems, and other computer-based design aids whose logic follows examples of success can only have limited application,” Petroski writes. Interestingly, Petroski points out that mistakes are more easily made because it still requires the human to ask the correct questions, to provide the correct scope, and to install checking mechanisms.

This book is a valuable read for program managers, engineers, and other acquisition professionals. It helps put into perspective how the complex systems demanded by today’s warfighter cannot necessarily be developed and delivered in a fail-proof manner. It illustrates that our ability to learn from mistakes through risk-reduction prototypes and “failing fast” during our development process can increase our ability to solve complex problems and deliver a safer capability in a more efficient and cost-effective manner.

The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail



Author(s):
Clayton M. Christensen

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Reviewed by:
Aileen Sedmak
Deputy Director for Systems Engineering Policy, Guidance, and Workforce, Office of the Deputy Assistant Secretary of Defense for Systems Engineering

Publisher Summary

In this revolutionary bestseller, Clayton Christensen demonstrates how successful, outstanding companies can do everything "right" and yet still lose their market leadership—or even fail—as new, unexpected competitors rise and take over the market. Through this compelling multi-industry study, Christensen introduces his seminal theory of "disruptive innovation" that has changed the way managers and CEOs around the world think about innovation.

While decades of researchers have struggled to understand why even the best companies almost inevitably fail, Christensen shows how most companies miss out on new waves of innovation. His answer is surprising and almost paradoxic: it is actually the same practices that lead the business to be successful in the first place that eventually can also result in their eventual demise. This breakthrough insight has made *The Innovator's Dilemma* a must-read for managers, CEOs, innovators, and entrepreneurs alike.

Review

The Department of Defense has a history of successfully pushing technological innovation to advance America's military dominance and to benefit citizens—GPS technology, auto-injector syringes (the basis for EpiPens), and digital photography to cite a few. Yet, Christensen points out that an organization's very success and capacity, born from making the "right decisions" at critical points, can actually hamper future success in the face of changing mission, technologies, and threats. To meet this challenge, Christensen examines innovation theory and how organizations can build a structure to sustain yesterday's successes and design new technologies that result in the next disruptive innovations.

Christensen describes two types of technologies: sustaining and disruptive. Sustaining technologies improve a current technology's performance and typically involve making incremental improvements in the performance of products that have an established role in the market; large organizations typically focus on sustaining technologies. Christensen asserts that many of these same large organizations have problems anticipating and responding to disruptive technologies, or innovations that solve problems before the market recognizes the need. These technologies eventually disrupt the existing market, displacing the established market leaders and alliances. Larger, more storied organizations are not insulated from disruptive technologies. Christensen says, "Huge size constitutes a very real disability in managing innovation."

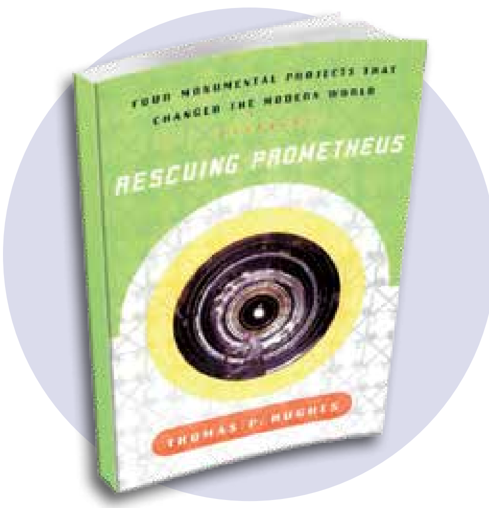
While Christensen seems to paint a grim picture for large organizations, he presents a methodology that can increase the organization's ability to identify, develop, and successfully bring to market emerging, potentially disruptive technologies before they overtake the traditional sustaining technology. The first challenge facing an organization is the lack of available data: "Markets that do not currently exist cannot be analyzed," and one cannot predict what technologies will be embraced by the market or the probability of success. Christensen proposes that organizations engage in discovery-driven planning, which operates on "learning by doing." The key obstacle to success with this approach is the stigma of failure. He is clear though that "failure is an intrinsic step toward success." This is addressed by organizations leaving room for, and in fact embracing, failure in the planning phase and being willing to make an investment in what may be a potentially disruptive technology. "In reality, spinning out is an appropriate step only when confronting disruptive innovation."

Christensen continues that once a potentially disruptive technology is identified, organizations must circumvent the hierarchy and bureaucracy that can stifle the free pursuit of creative ideas. He suggests that organizations provide experimental groups within the firm—similar to Lockheed Martin's "Skunk Works"—with a free rein to develop and quickly market the new technology. "With a few exceptions, the only instances in which mainstream firms have successfully established a timely position in a disruptive technology were those in which the firms' managers set up an autonomous organization charged with building a new and independent business around the disruptive technology," he says.

The Innovator's Dilemma is of interest to requirements and acquisition community stakeholders because the department relies on both sustaining and disruptive technological solutions to maintain its advantage. By applying the methodology that Christensen outlines along with a tolerance for failure, executives, program managers, and engineers are more likely to successfully identify and investigate new disruptive technologies that can be adopted, developed, and supplied to the warfighter.

FOR RISING LEADERS

Rescuing Prometheus: Four Monumental Projects That Changed the Modern World



Author(s):
Thomas P. Hughes

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Softcover, 372 pages

Reviewed by:
Dr. Alexander H. Levis
Head, System Architectures Laboratory
George Mason University

Publisher Summary

Rescuing Prometheus is an eye-opening and marvelously informative look at some of the technological projects that helped shape the modern world. Thomas P. Hughes focuses on four postwar projects whose vastness and complexity inspired new technology, new organizations, and new management styles. The first use of computers to run systems was developed for the SAGE air defense project. The Atlas missile project was so complicated it required the development of systems engineering in order to complete it. The Boston Central Artery/Tunnel Project tested systems engineering in the complex crucible of a large scale civilian roadway. And finally, the origins of the Internet fostered the collegial management style that later would take over Silicon Valley and define the modern computer industry. With keen insight, Hughes tells these fascinating stories while providing a riveting history of modern technology and the management systems that made it possible.

Review

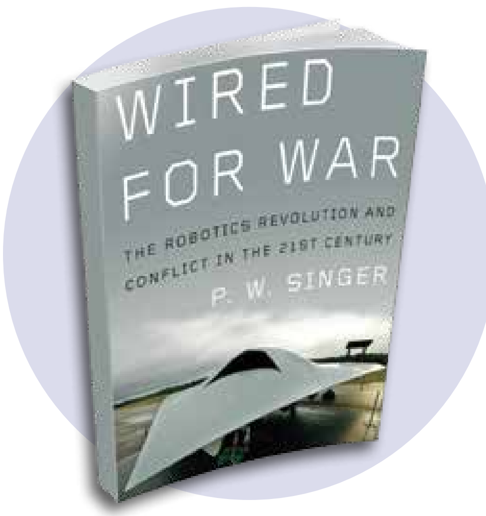
Clearly, this book is of much interest not only to acquisition professionals, but to all Department of Defense personnel because the stories in Hughes' book explain a lot of the how and why we are where we are now. The people described in the book and the technological developments that resulted from their efforts have defined the "connected world" we are experiencing now.

The second half of the 20th century saw the development of several technologies that have come to define the beginnings of the 21st century. As Prometheus gave fire to mankind and changed the way humans lived, these technologies have ushered the connected world. What is particularly significant is that three of the four technological developments and the systems engineering methodology that evolved from them were the result of basic and applied research by the Department of Defense.

Hughes presents the history of four projects and includes a chapter on the evolution of systems engineering. The first project he describes is the Semi-Automatic Ground Environment (SAGE) air defense system. The need to track incoming missiles led to the interconnection of radar sites by telephone lines; the need to store the radar data led to the development of the magnetic core memory and the transformation of IBM from a typewriter company to a computer company; the need to generate the tracks led to the first computer languages and programs. It also changed the technologies for Command and Control forever. The second project described is the development of Atlas, the first Intercontinental Ballistic Missile (ICBM). A particular challenge here was the concurrent design of the many parts of the system while simultaneously conducting basic and applied research on parts of it. This had two major impacts: the development of systems engineering management to handle the complexity of the endeavor and the development of key technologies that enabled the U.S. space program. The third project is the development of the Advanced Research Projects Agency Network (ARPANET), the precursor to and technology basis of the Internet. The original Advanced Research Projects Agency (now Defense Advanced Research Projects Agency, or DARPA) program connected computers in a few universities forming the first computer network. While the first two projects, SAGE and Atlas, were focused on the development of specific systems and had many contractors and subcontractors, this did not have a very direct military application and involved primarily academic efforts. Computers connected through telephone networks (the Bell system) and exchanging data through packet switching were expected to enhance Command and Control capabilities. No one really foresaw how e-mail and the development of the Web browser would connect the world. The fourth project is a different one; it is the complex story of the Central Artery/Tunnel development in Boston. The complexity of this project did not derive from the engineering challenges (engineers had learned long ago how to dig holes), but from the social, economic, environmental, and political complexities of carrying out a large project in an urban environment. Note that the purpose of the project was also connectivity—to facilitate North-South traffic through Boston and improve access to Logan Airport. Subsequently, turmoil ensued in the form of responses to the project of many public interest groups, state organizations, and federal entities (from the Environmental Protection Agency to the Federal Highway Administration that funded part of the project).

What was common to all four projects was that they were large-scale, they involved multiple technologies, they were executed by a large number of contractors and subcontractors, and they affected diverse sets of people by changing the way they were functioning. Such projects posed a new challenge both at the technical and managerial perspectives. This gave rise to systems engineering, and systems engineering management methodologies and tools that are still evolving even though they are deeply embedded in the way we work. One cannot help but wonder how the chief systems engineers of the Pharaohs managed the construction of the Pyramids without the technologies and tools available today.

Wired for War: The Robotics Revolution and Conflict in the 21st Century



Author(s):
P. W. Singer

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Reviewed by:
Sydney Coelho
Former Publications Assistant
Defense ARJ

Publisher Summary

In *Wired for War,* P. W. Singer explores the greatest revolution in military affairs since the atom bomb: the dawn of robotic warfare. We are on the cusp of a massive shift in military technology that threatens to make real the stuff of *I, Robot* and *The Terminator.* Blending historical evidence with interviews of an amazing cast of characters, Singer shows how technology is changing not just how wars are fought, but also the politics, economics, laws, and the ethics that surround war itself. Travelling from the battlefields of Iraq and Afghanistan to modern-day "skunk works" in the midst of suburbia, *Wired for War* will tantalize a wide readership, from military buffs to policy wonks to gearheads.

Review

In his 2009 book *Wired for War: The Robotics Revolution and Conflict in the 21st Century*, P. W. Singer answers a plethora of technological questions generated by the complexities of digital warfare—questions to which answers have become increasingly vital for the acquisition professional as well as the warfighter on the battlefield. Citing films such as *The Matrix* and *A.I.* in comparison, Singer illustrates the very real use of robotics in modern warfare, and to what extent such technologies might be used to meet an existing or perceived threat. Leveraging his knowledge and background as both a robotics enthusiast and a researcher of private military firms, Singer describes how the robotics industry and the government are squaring-off on the battlefield and beyond. From war tactics and lasers, to super-bots and artificial limb construction, Singer takes his readers on a guided tour of the artificial intelligence industry and neatly points out the pros and cons of how society interacts with machines.

Readers familiar with the art and tactics of warfare know that "a dense set of rules defines what is right or wrong in battle. These rules find their origin in everything from the Bible to the Geneva Conventions" (Singer, p. 382). What would happen, however, if these rules were changed and redefined? Singer suggests that while technology has its advantages, uncertainty remains about how to contain such rules and laws of combat should something go awry; and while governments around the globe are aware of possible problems associated with artificial technology, they are still in the beginning stages of defining what these problems might be and how to combat them.

Acquisition professionals will find this book helpful not only because of what it has to offer [in the view of this reader, significant insight into the world of technological warfare], but also because of what it does not. In fact, they may find themselves reconsidering the decisions they make—decisions that once seemed so simple may now harbor new and unseen consequences that could potentially put the warfighters they are trying to support and protect on the battlefield in greater danger. As Singer concludes from his research, a vast amount of grey areas in developing and navigating the complexities of digital warfare are challenging, and will continue to challenge, the defense acquisition professional. Singer presses his readers to keep this in mind when weighing any decisions that have the potential for not only a war with people, but a war with machines.