

REVIEWS

Megawatts and Megatons: A Turning Point in the Nuclear Age?

by Richard L. Garwin and Georges Charpak (Alfred A. Knopf, New York, 2001, 412 pp.) \$30. ISBN 0-375-40394-9

Two documents by the Bush administration have focused media attention on nuclear issues. The publication in May 2001 of *National Energy Policy* (currently the subject of a General Accounting Office suit against the administration to gain access to information about the meetings leading up to the study) advocated that “the President support the expansion of nuclear energy in the United States as a major component of our national energy policy.” Whereas the Clinton administration’s attitude towards nuclear energy ranged from hostile to grudgingly neutral, the current administration has endorsed nuclear energy. The American utility industry has been slow to follow this lead. In addition to *National Energy Policy*, the administration has sent to the Congress a long-delayed recommendation to go forward with the proposed Yucca Mountain geologic repository for high-level radioactive waste. These actions have stirred up the debate on nuclear power.

Similarly, the recently leaked *Nuclear Posture Statement* has reopened debate on the role of nuclear weapons in the post-cold war world, including issues surrounding the Comprehensive Test Ban Treaty (CTBT), the need for testing of nuclear weapons, and the development of new nuclear weapons. Thus the current administration’s documents, one public and one leaked, have laid a foundation for serious discussion of nuclear power and nuclear weapons. Richard Garwin and Georges Charpak’s recent book will be a significant help for those trying to understand the technical and policy issues.

Richard Garwin is an American theoretical physicist who has been involved in US science policy since working in the Manhattan Project. He is a member of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. Garwin, well known to scientists who follow public policy issues, received the American Physical Society’s Szilard Award in 1976. Georges Charpak is a French experimental physicist, and a member of the French Academie des Sciences and the US National Academy of Sciences. He received the 1992 Nobel Prize in physics.

Garwin has advised the U.S. government for many decades on technology and nuclear weapons. This book addresses comprehensively both nuclear power and nuclear weapons. Unlike many articles and books on these subjects, this was written by authors who have first-hand and extensive experience with the technologies and the policy debates. The writing is clear, presents the information, and allows the reader to reach conclusions as to the weight of evidence. Enough data is presented so the reader can do back-of-the-envelope calculations to check some conclusions, such as the relative risks of nuclear and coal plants. Although the authors are, I believe, favorable to nuclear power, they do not support one of the beliefs of most nuclear power advocates, namely that reprocessing should be pursued. Reprocessing leads to separating the plutonium out of spent fuel. Their lead-in to this issue: “For an engineer, a ton of plutonium can produce one gigawatt of electricity for a year; for an economist, a ton of plutonium has a negative value of \$25 million (this is the additional expenditure required to enable a ton of plutonium and 20 tons of MOX fuel to be sold at the same price as 20 tons of enriched uranium fuel of the same energy value in a light-water reactor); for Saddam Hussein, it can make 200 nuclear bombs.”

The authors also treat nuclear fusion, presenting a primer on the topic, and they review many types of reactors, including boiling water, pressurized water, CANDU, gas reactors, and breeders. They do not advocate breeders. The fuel cycle is addressed, including reprocessing and waste disposal. Energy policy issues are treated, including global warming. They favor renewables and energy efficiency.

The book treats nuclear weapons in detail (restricted, of course, by classification) and introduces those unfamiliar with the policy issues to "sufficiency," the role of the International Atomic Energy Agency in non-proliferation, the politics of the CTBT, and the history behind US and French nuclear forces. They make clear that making a nuclear weapon is not easy and that the critical step is getting the fissionable material. The current debate on how to dispose of weapons plutonium is treated as a significant issue. They address the dual-track approach (vitrification and MOX) advocated by the Clinton administration, and the "spent fuel standard" introduced by the National Academy of Sciences. Garwin has long been an advocate of arms control. They write "the threat to the nuclear forces themselves, before they could be launched and before they could reach their targets, contributed to an inflation of strategic nuclear forces in the United States and the Soviet Union that went beyond all military logic." They conclude "it is appalling to the authors that the literate peoples of the world do not take feasible steps to reduce the threat of 30,000 or more nuclear weapons still present in the world."

The book is an updated version of a 1997 French volume by these authors, *Feux Follets et Champignons Nucleaires*. It can usefully be read by anyone interested in either nuclear power or nuclear weapons policy. Although in parts the book does require following technical details, it should be read by new Congressional staff members and other newcomers to these debates to learn about these tough issues.

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Space Weapons, Earth Wars

by B. Preston, D. Johnson, S. Edwards, M. Miller and C. Shipbaugh,
Project AIR FORCE, (RAND, Santa Monica, 2002), pp. 201, ISBN: 0-8330-2937-1

This book coldly, very coldly, examines the subject of weapons in space. The book--really a report to the Air Force--describes the various types of space weapons, how they might be deployed, and how they might be employed in battle. It describes how these weapons might be acquired (by the US and/or other nations) and, in a final section, it describes the advantages and limitations of such weapons.

The report initiates its discussion by noting that it is the Air Force's policy to fully use space for national security. And "fully" means, it notes, "beyond intelligence, surveillance and reconnaissance, warning, position location, weapons guidance, communications and environmental monitoring." In short, real weapons. The report states that it "does not present an argument either for or against space weapons but instead describes their attributes and sets out a common vocabulary." But it does observe that "although there is currently no compelling threat to US national security that could not be addressed by other means, the United States could consider space-based weapons as a component of its vision of global power projection for 2010 and beyond." The report then simply goes on to analyze, in detail, space-based weapons.

The report considers directed energy weapons (lasers and particle beams), kinetic energy weapons, and space-based conventional explosives. (Weapons of mass destruction are prohibited by treaty, and the now-defunct ABM Treaty prohibited missile defense in space.) For each, it describes in considerable detail the weapon's uses, time lines, and absentee ratios.

For example, the report considers space-based lasers employed for boost-phase missile defense. Taking a hydrogen fluoride laser of reasonable strength, and a reasonable kill criteria (that however might be ten times more demanding if the missile is hardened), they then calculate how many missiles one laser can destroy. There isn't much time for a kill as the laser doesn't penetrate below 15 km because of atmospheric effects on the laser beam, and the missile burns out at about 50 km. Since the laser mirror must slew from one target to another, a laser can only take out three missiles; four missiles would saturate a laser. In any constellation of lasers, most of the lasers are on the other side of Earth, so the absentee ratio is 24; that is, 24 lasers would be needed, and more if you want the saturation to be higher. The fuel needs are about 200 kg per kill and it takes 25 kg to orbit 1 kg. Furthermore, but not commented upon in the report, the war head keeps going with somewhat reduced range, so an ICBM launched from North Korea and aimed for a ranch in Texas might come down in San Francisco.

This example leads one to respect the many detailed calculations that make this a valuable report, because the report is meant to turn loose talk into serious consideration. It seems to me that such details would lead any reasonable person to dismiss lasers for boost phase defense. However other uses of space weapons, such as having cruise missiles launched from satellites, delivering an explosive warhead to destroy large naval ships or highly defended surface targets in (say) 30 minutes seems possible employing only 5 satellites. Now the cost is about 50 kg for every 1 kg delivered, but the appeal to the military of being able to project power anywhere in the world on a half hours' notice must be very attractive.

In the sections on acquisition of space weapons, the report gives separate consideration to several alternative scenarios: a US decision that is either deliberate or incidental, a decision that is either incremental or monolithic (all-at-once), a decision that is multilateral (in concert with other nations) or unilateral, etc. This discussion is extensive (almost 50 pages) and exhaustive. In the concluding section both the advantages and the limitations (large numbers, logistic expense, legal aspects, predictability of orbits, etc.) of space weapons are reviewed.

Although I couldn't find a discussion of this point in the report, it seems to me that, if you found a weapon passing over your sovereign space, you would declare it an act of war and shoot it down. In this day and age many nations have just such capability, and those who don't are usually friendly with a nation that does have the capability, so isn't deploying such a system in itself an act of war? Am I being old-fashioned?

The book, as I said, is very cold, i.e. it displays no emotion but only pure military and technological considerations. I suspect the authors are rather proud of this fact. But for readers (like me) who believe that we must do all we can do to prevent the spread of weapons into space, this book is hard medicine to take. In fact, as I read more and more of the book, the deployment of space weapons seemed more and more inevitable and I found myself getting more and more sick.

But perhaps my illness about weapons in space is a result of wrong thinking, conditioned by long decades of reading articles, books, and reports on the use of nuclear weapons while seeing the US acquire tens of thousands of nuclear weapons for everything from depth bombs, torpedoes and artillery shells to intercontinental missiles. Perhaps if we hadn't thought quite so

much--made the use of nuclear weapons seem so inevitable, ordinary, comfortable, advantageous, and necessary--we wouldn't have acquired so many.

In sum, leaving my diatribe aside, this book is recommended to those wishing to be informed about space weapons. I am not aware of any other book that is as comprehensive. Whether you are for or against space weapons this book provides the material upon which to base your arguments. If you are interested in the military use of space or in national security policy, this is a book for you.

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“Inviting Disaster - Lessons from the Edge of Technology: An Inside Look at Catastrophes and Why they Happen” by James R. Chiles, HarperBusiness, 2001 (hard-cover \$28.00, paperback \$19.00 at www.amazon.com)

Since I have worked on problems involving risk assessment and management (RA/RM) for engineered systems, and even testified in Congress on good vs. bad applications thereof, I was very eager to review this book. In anticipation of receiving my review copy from Art Hobson, our P&S book editor, I read the glowing editorial and readers' reviews posted at amazon.com. Sadly, as I struggled to read the book, my high expectations were dashed. From the retelling and forensic analysis of over 50 cited natural or man-made “disasters, calamities and near misses” spanning the last 200 years, I found it very difficult to identify and distill any clear “lessons learned” for preventing and mitigating future occurrences.

Famous accidents are discussed in detail, reflecting quite a bit of research and an honest effort by the author to understand their root causes and to uncover the underlying mechanical or human factors involved. They include: the Thresher submarine sinking, Apollo 1 and 13 fires, the Challenger space shuttle explosion, Bhopal, the Chernobyl and Three Mile Island nuclear reactor accidents, the Hubble Telescope's distorted mirror and the Concorde blowup. There is a lot of good source bibliographic material and some strong human stories in the book, and even some heroes who stand out (like Admiral Rickover, and cool aircraft and pilots). However, I found chapters and sections to be mostly scattered and disorganized, jumping around among events, times, and types of systems. Each chapter is a mish-mash of accidents and ideas, although its title indicates that it was intended to focus on a single theme: the dangers of insufficient testing and how destructive testing can verify design safety; how emergency preparedness planning serves as antidote to failure; what are the limitations of humans in the loop; how lack of foresight or of understanding all possible failure modes can prevent proper system design and operation, etc.

There is no disciplined chronological progression, nor any coherent analysis of inherent risk and safety margins that could be provided in design, construction, test, operation, and maintenance phases for increasingly complex technological systems, operated by fallible humans. No simple and basic lessons are spelled out in this disjointed discussion of selected disasters about how we can successfully design and manage engineered systems of increasing technological complexity and interdependencies. No evidence is presented that the scientists, engineers, and trained technical system operators have actually learned and transferred to practice any valuable lessons from the analysis of famous failures.

A chapter dedicated to the discipline and tools of risk assessment and management, illustrated by both notable failures and successes, would have been quite valuable in educating lay readers. Few of the common RA/RM concepts (such as the probability of occurrences, statistical testing, preventive maintenance, risk profile, safe designs, construction, and fail-safe operation practices) are either explained or illustrated in the book, so as to teach about key concepts. I looked in vain for evidence or mention of key steps in any disciplined failure analysis: hazard identification, absolute or relative risk ranking, single point

failures, common-cause failures, and failure chains, event tree and criticality analysis. Similarly, I tried in vain to find examples of successful consequence mitigation strategies for any foreseen engineered system failure, such as redundancy, overdesign, endurance testing and training programs.

By the end of the book, I was quite fatigued by the jumping around from ancient to new accidents, and among the many and diverse types of engineered systems such as cars, planes, ships, boats, helicopters and spacecraft, chemical and propellant factories, offshore oil platforms, etc. Although the book has a good list of resources and a well-organized index, its disaster stories could be both informative and amusing, and its sensationalist style could be entertaining for some lay readers, I cannot in good conscience recommend it to scientists or engineers

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Disciplined Minds, by Jeff Schmidt

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The title, like the book, represents the double-edged sword of professional training. Does one's mind become more disciplined in graduate school—more focused, more devoted to one's subfield? Or is the mind of a graduate student disciplined into obeying the structure and hierarchy unique to one's field of study? In his book, author Jeff Schmidt explores the development of a professional and highlights those factors which he believes perpetuate the insular nature of the professional world.

The book begins with the development and behavior of a professional. Schmidt argues that a basic distinction must be made between a professional and a non-professional: the use of political skills (p.41). A professional, by his definition, is a person that an institution entrusts to maintain the ideologies of that institution. They have been trained to perpetuate the image of the institution.

This kind of professionalism comes at a price. In order to perpetuate the institution's ideologies, the human mind has two options: to genuinely believe in those ideologies-on the clock and off, or only to believe in them when the clock is ticking. Most people do not enter an institution in full agreement with every aspect of that institution's ideologies, so there is some break-in period for novitiates. Schmidt talks about this in the context of graduate school as a "boot camp," where ideals are homogenized into the broth of the institutional soup.

That is, there is an inherent sacrifice of one's own role in the creative progress of the professional field while one is a drone. The example that he describes in much detail is the plight of the graduate student, who must sacrifice time, energy and income for the sake of the doctoral degree. Schmidt believes that the sacrificial nature of graduate school is necessary in order to prepare the student for the transition into a hierarchical system.

Drawing upon his personal experience as a physics graduate student at University of California-Irvine and stories of other students, Jeff Schmidt's book is an exploration into the developmental stages of a young professional. It is, at times, hard to read his book without sensing his bitterness towards his graduate school days leaking through. Perhaps it is necessary for us to be exposed to this bitterness in order to understand the effects that such clashes with bureaucracy can have on an individual.

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