Schmincke's contribution reads very well, with each chapter effectively building on the previous ones. I appreciate the opportunity that I have through his book to improve my efforts to educate future volcanologists.

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Whole World on Fire: Organizations, Knowledge, and Nuclear Weapons Devastation

Lynn Eden
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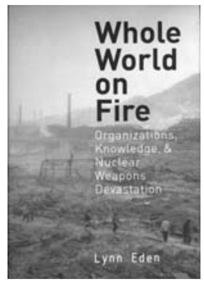
Sometimes a researcher entering a new field will "discover" a fact that has been well known, if differently expressed, by those who have worked in the area for an extended period of time. If the field of study is socially and politically sensitive, newcomers may well conclude that their discovery had been concealed as part of some conspiracy to deny the truth. Lynn Eden, associate director for research at the Center for International Security and Cooperation at Stanford University, and MIT scientist Theodore Postol, who was her collaborator for part of *Whole World on Fire: Organizations, Knowledge, and Nuclear Weapons Devastation*, seem to have no other reason besides conspiracy for their conclusion that the US government and its nuclear target planners deliberately failed to take into account fire damage from nuclear wars.



In my first formal study in 1980 of the effects of nuclear weapons and the American system for matching weapon to target, I learned that to a first approximation a low-yield nuclear explosion, say one or two kilotons, killed people by nuclear radiation, primarily neutrons. Blast is the predominant effect of weapons with yields in the range of tens of kilotons and up to, perhaps, 100 kilotons. Still-larger weapons are primarily useful for their incendiary effect, which Hans Bethe pointed out before the first hydrogen bomb was designed and before the Teller–Ulam solution to the problem of constructing a thermonuclear weapon had even been imagined. Bethe drew clear maps of the comparative effects of a 10-kiloton and a 10-megaton nuclear explosion in a 1950 *Scientific American* article.

Eden begins *Whole World on Fire* with a dramatic description of the effects a 100-kiloton bomb would have if exploded at ground level at the Pentagon, just across the Potomac River from Washington, DC. She then compares the 100-kiloton device to a 10-kiloton weapon also detonated on the surface. Not surprisingly, given the specific case, she finds that the radius at which the 10-kiloton bomb would ignite buildings and trees is greater than that at which its blast would destroy buildings. But the result depends on the nuclear targeteer's choosing to reduce blast effects. In fact, the radius of blast damage depends strongly on the altitude of the explosion, because the shock wave from an air burst is enhanced by shock waves that are reflected from the ground and moving much faster through the heated air near the ground. Unless a nuclear weapon were being used to produce ground shock or dig a crater, no skilled planner would choose anything but an air burst.

The effect of a nuclear-weapon air burst was known to the Manhattan Project scientists and ordnance specialists, and it accounts for why the Hiroshima and Nagasaki war shots were set to explode at about 1800 feet above the ground. The US Strategic Bombing Survey maps of damage to Hiroshima confirm that the area destroyed by blast was far greater than that destroyed by the mass fires, formerly called firestorms. The reproduced map in Eden's book, which leaves out the area damaged by blast, makes it appear that the entire damage was due to incendiary effects. Eden and Postol's computations would have been more persuasive had they chosen their burst altitudes to correspond with what a US Air Force nuclear planner would have selected: modestly high air bursts, which would have maximized blast destruction, with some slight cost to the effectiveness of the thermal radiation.

From what I can tell from Eden's book and my own readings on nuclear operations planning, I saw no conspiracy to hide the incendiary effects of large nuclear weapons. One might reply that damage requirements were established and that weapons types were designed and selected on the basis of blast kill, not fire damage. This argument has an element of truth to it, but as Eden herself shows, there were no reliable computations during World War II and the early cold war on which quantitative estimates of mass fires could be based. Such algorithms did not appear until the 1980s.

Where Eden finds government conspiracy to hide the effects of fire and thus reduce the apparent horror of nuclear war and allow the armed forces to purchase many more weapons and delivery systems, I see government at work as usual (see my opinion piece in PHYSICS TODAY, January 2005, page 48). Poorly paid people worked in great secrecy and under real pressure—psychological, because of the awful nature of the deeds they contemplated, and real, because of the government's perceived need to optimize its nuclear strategy—to do the jobs they were asked to do. I also see inertia at work, for a government agency at rest tends to remain at rest. Although strategic nuclear weapons are virtually an economic free good today, that was not so from 1945 until the 1970s. Every round was precious, requiring the most effective possible use.

Eden is on surer and more interesting ground when she departs from her conspiracy theory and instead asks how a new mode of thinking gradually replaces entrenched patterns of thought. If Eden had expanded on the question, her book would have been considerably more interesting than her and Postol's diatribe against the atomic establishment. It is hard for new ideas to become assimilated, and it does not happen immediately, nor would one want to lose some of the inertia that protects the scientific enterprise from being overwhelmed by unsubstantiated results and unproven theories.

Eden points out, almost as an aside, that it is possible for engineering facts to be available, but not necessarily to those responsible for using them in a new field. She gives credible discussions of such a situation played out in the sinking of the *RMS Titanic* by an iceberg (the metal had become brittle by cold salt water and so was very vulnerable), in the design of the Tacoma Narrows suspension bridge (dynamic air flows and the structural response to vortices were not tools of the structural engineer), and in the failure of windows in various glass-curtain-wall skyscrapers. Such cases are far more interesting than nuclear target planning; they are worthy of a great deal of study by engineers and physical scientists because they can be discussed completely, with no need to hide any details behind a wall of secrecy.

Eden began what could have been a marvelous review of the hubris of top-ranked engineers: men and women who believe they are masters of all that is needed to build a given structure, only to find out later that confounding information already exists. The author demonstrates that getting the right information to the right people working on the cutting edge is difficult, and that engineers and scientists can believe they are doing what is right even though they have unknowingly made terrible mistakes. Instead of a polemic about the US nuclear weapons enterprise, Eden and Postol could have written a far more valuable analysis of the commonplace in engineering where, in fact, many people's lives are at risk.

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