Report on POPA Activities

At its meeting on October 23, the APS Panel on Public Affairs approved a discussion paper prepared by its members on one issue—the proposed Moon-Mars program—and initiated studies on two additional topics—science advice to Congress and the link between nuclear power and nuclear proliferation.

Moon-Mars mission

The APS issued the Moon-Mars report along with a press release on November 22. (Both the press release and the report are on the POPA website, http://www.aps.org/public_affairs/index.cfm.) The report addresses a proposal by President Bush on January 14, 2004, for a return of humans to the Moon by 2020, followed by human exploration of Mars and other destinations. The executive summary of the APS report asserts that "Very important science opportunities could be lost or delayed seriously as a consequence of shifting NASA priorities toward Moon-Mars. The scientific planning process based on National Academy consensus studies implemented by NASA roadmaps has led to many of NASA's greatest scientific—and popular—successes. We urge the Federal Government to base priorities for NASA missions on the National Academy recommendations."

The report also states that "extraordinary scientific and technological difficulties confront President's Bush's vision for a Moon-Mars initiative. The budget for the proposed program remains very imprecise and is expected to grow substantially. The constraints that inevitably will be imposed on other federal scientific programs are already evident, especially within NASA. Before the United States commits to President Bush's proposal, an external review of the plans should be carried out by the National Academy of Sciences."

The budget passed by Congress in November included a 5% increase in NASA's budget. Sean O'Keefe, the NASA administrator, called the budget victory "as strong an endorsement as anyone could have hoped" for the national space policy outlined by the president in January.

Other initiatives

Ever since the demise of the Congressional Office of Technology Assessment, there have been concerns about the adequacy and quality of science advice given to Congress. Two Congressmen have recently drafted separate bills creating some form of technology assessment capability, but the bills have not met with much success. At its October meeting, POPA created a subcommittee to (1) assess the methods Congress has for obtaining scientific advice; (2) identify any gaps in those methods and (3) identify ways to fill any gaps. The subcommittee will report back to Congress at the January meeting.

On another front, there has been growing concern that the development and expansion of nuclear power is a significant proliferation threat. Congressional staffers have asked the APS for some guidance on this issue. As a result, POPA created a subcommittee to (1) frame the issue of proliferation resistance and fuel cycles; (2) identify general approaches for reducing proliferation risks; and (3) recommend technology pathways that can be applied to reduce proliferation risks at present, in the near term and in the long term. This subcommittee will also report in January.

Barbara Goss Levi
FPS representative to POPA

ARTICLES

Underestimating the Consequences of Use of Nuclear Weapons: Condemned to Repeat the Past's Errors?

Lynn Eden

This article draws on Lynn Eden, *Whole World on Fire: Organizations, Knowledge, and Nuclear Weapons Devastation* (Ithaca, NY: Cornell University Press, 2004)

Seriously studied for almost sixty years, nothing would seem better understood than the effects and terrible consequences of the use of nuclear weapons.[1] Yet, surprisingly, for decades, one far-reaching effect—the mass fire damage caused by "firestorms"—was neither examined in depth nor widely understood. This matters because, for modern nuclear weapons, under almost all conditions and for many targets of interest, the range of devastation from mass fire substantially exceeds that of damage from blast. Once mass fire began to be studied analytically and through reanalysis of empirical experience, the quite well-developed findings were not widely accepted. There may be somewhat greater acceptance now, but, when it comes to nuclear operations, understanding by physicists is not enough. Knowledge has to be incorporated into organizational procedures, specifically, the algorithms used in strategic nuclear war planning.

There is currently a low level of effort to develop a methodology to predict collateral fire damage, but as of mid-October, 2004, fire damage prediction is still not incorporated into the U.S. strategic nuclear war plan–that is, as a mechanism of destruction for deliberately targeted forces and installations. There is no program underway to do so.[2]

Underestimating the damage caused by nuclear weapons is an important part of the historical explanation for the inflated force requirements—"overkill"—that led the United States and Soviet Union to build nuclear arsenals in the tens of thousands of warheads. But underestimating damage matters importantly now as well. To paraphrase George Santayana, those who do not understand the past may well be condemned to repeat its errors.

Particularly salient today are regional conflicts in which a decision or threat to use nuclear weapons would in all likelihood be based on a severe underestimate of the damage that could result. Indeed, in the South Asian crisis of May 2002, the United States specifically sought to warn the leaders of India and Pakistan of the consequences of a nuclear exchange. However, a U.S. defense intelligence assessment prepared for that purpose was based on blast effects alone. The study estimated that twelve million people would be killed, *but it did not include deaths from mass fire.*[3] If it had, the estimate would undoubtedly have been much higher.

Beyond the very important possibility of underestimating damage and death from nuclear weapons in the event of use, there are similar kinds of phenomena in which important aspects of the physical world are not well understood or, if understood, are not incorporated into political decisions and organizational procedures. Such phenomena are more common than might at first be thought.

In what follows, I first explain what I mean by mass fire. I then make some bald assertions, much more fully argued and documented in *Whole World on Fire,* about the predictability and range of mass fire. I very briefly summarize why predictions of mass fire damage were not developed for many years. I also briefly summarize how a small team, led by physicist Harold Brode at Pacific Sierra- Research, developed a methodology to predict nuclear fire damage. I explain what happened to that work. And I close by drawing out some implications for other areas of policy.

Mass fire is roughly synonymous with the more common term "firestorm"—though physicists tend to prefer the former term. A nuclear mass fire can occur in an area containing a fuel load typical of a city or suburb. A nuclear detonation would first cause myriad simultaneous ignitions over this large area. These fires would begin to coalesce and to heat an enormous volume of air that would rise. Like a gigantic bonfire, this rising hot air would cause cooler air near the surface to be sucked in from the periphery. This air would move at hurricane force toward the center, become superheated, and rise—causing additional hurricane winds to rush in from the periphery and further intensifying the mass fire. No one within the area would survive.[4]

Such mass fires are fundamentally different from the famous fires that destroyed London, Chicago, and San Francisco, the vast forest fires of the late nineteenth century that swept the Great Lakes states, and the Cerro Grande fire that nearly destroyed Los Alamos National Laboratory in 1999. These were not mass fires, simultaneously set over vast areas, but large propagating "line fires." Such line fires are highly destructive, but do not occur in the same time frame, nor with the scale and intensity, of a mass fire. The mass fire set at Hiroshima by a 15 kiloton atomic bomb, for example, completely burned out an area of 4.4 square miles within hours, not days.[5]

Some have argued that although nuclear mass fires could be highly destructive, they would be subject to weather and other conditions, and therefore cannot be reliably predicted. It has also been argued that the probability and range of such fires is not as predictable as damage from nuclear blast. Finally, it has been argued that for the specific targets of interest to war planners, the range of fire damage is not greater than the range of blast damage. However, the work of Harold Brode and his collaborators, as well as that of MIT professor Theodore Postol, establishes that mass fire creates its own environment, and therefore is highly predictable. (Think of a piece of the sun being brought to earth.) Mass fire and extensive fire damage would occur in almost every circumstance in which nuclear weapons were detonated in a suburban or urban area. The circumstances in which mass fire damage would not occur—for example, during torrential rainstorms—are rare, and their probabilities are calculable in advance. Although weather can affect the range at which fires will occur, this variation can be reasonably well predicted. Nuclear fire damage is, in fact, as accurately predictable as blast damage: The uncertainties in the range at which mass fire would cause damage are no greater than the uncertainties associated with blast.[6] Finally, many targets of interest to war planners, such as military, command, industrial, and political targets, are co-located in urban or suburban areas, and for nuclear weapons of approximately 100 kilotons or more, the range of severe damage from fire is likely to be significantly greater than the range of severe damage from blast. Under most circumstances, damage from mass fire would extend two to five times farther than blast damage.[7]

Why were predictions of fire damage not developed for many years? The answer goes back to before World War II. Fundamentally, organizations can only solve the problems they set out to solve. Those involved in air target intelligence focused on being able to destroy specific installations with high-explosive blast weapons. Despite excursions into incendiary operations in World War II, the emphasis remained on precision targeting with high-explosive bombs. The emphasis on blast damage can vividly be seen in the end-of-the-war U.S. Strategic Bombing Survey. According to a careful reading by Harold Brode, the multi-volume reports on Hiroshima and Nagasaki concentrated on structural damage due to blast. "[F]ire, although fully reported, was viewed as interfering with their objective of identifying and quantifying blast damage." [8]

Despite the inevitable area damage caused by nuclear weapons, the emphasis on precision targeting and blast damage carried over after the war into the early development of blast damage prediction in what became known as the VNTK system—the main tool for predicting damage, that is, blast damage from nuclear weapons for use in U.S. strategic nuclear targeting. There was no comparable development of fire damage prediction for many years following. Further, those involved in developing blast damage prediction—including such outstanding civil engineers as Nathan Newmark, a University of Illinois professor—were not intellectually equipped to predict fire damage. The whole process became self-reinforcing: what could be predicted seemed to those involved as inherently more predictable; what could not be predicted seemed inherently unpredictable.

This is not to say that some physicists were unaware of nuclear fire damage. Indeed, President Eisenhower's science adviser, George Kistiakowsky, wrote that because U.S. nuclear war planners "used blast effect as the only criterion of damage and neglected thermal radiation [and the] fires which will be caused by it... the question may be raised as to whether [it results] in overkill and will create unjustified additional 'force requirements.'"[9] Nonetheless, this insight was not used within the government to build expertise and develop knowledge about nuclear fire damage.

Beginning in the late 1970s, the Federal Emergency Management Agency (FEMA) and then the Defense Nuclear Agency (DNA), began to fund exploratory work for a small team led by Harold Brode at Pacific-Sierra Research to develop a methodology to predict fire damage for use in strategic nuclear targeting. Why did the government decide to fund this work—at Brode's initiative? In fact, it was not unusual for DNA to fund exploratory work. The question might better be asked as to why Brode did not choose to work on the problem earlier. In any case, the interest generated by the "nuclear winter" controversy beginning in late 1983 resulted in further funding for Brode's efforts—since where there's smoke, there's fire. By the early 1990s, Brode and his colleagues had teamed up with DNA, and also the Defense Intelligence Agency (DIA) and nuclear war planners from the Joint Strategic Target Planning Staff (JSTPS) to predict combined fire and blast damage to 50 and then 300 example targets. By the end of this process, they had demonstrated a method not only for predicting fire damage, but for incorporating those predictions into the government's VNTK system for predicting blast damage. Indeed, in early 1991, the government came close to incorporating fire damage predictions into nuclear war planning. However, the post-Cold War environment and an ultimate inability to persuade high-level military officers of necessity and feasibility led to the shelving of the project by year's end.[10] Although interest in predicting fire damage was revived in the mid-1990s, work is no longer being done to develop a combined method to predict fire and blast damage for use in strategic nuclear war planning—although some interest continues in predicting collateral fire damage.[11]

It is consequential that U.S. nuclear war planning does not take full account of the physical devastation that would occur were nuclear weapons to be used. Yet the implications of *Whole World on Fire* are broader than this. Like the VNTK system based only on blast damage, the representation of the physical world in documents, routines, and technologies may be inaccurate or incomplete. Many examples abound, from the construction of the *Titanic* (shipbuilders did not understand just how brittle was the steel plate used), to the failed design of the Tacoma Narrows bridge, to the lack of anticipation that a jet aircraft flying into the World Trade Center could also ignite fire from the thousands of gallons of jet fuel released into the building. Such situations probably cannot be altogether avoided, but the immediate correction of serious design errors in the Citicorp Center in New York and the John Hancock Tower in Boston (both built in the 1970s), points to the general solution: democratic accountability and open professional oversight.

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Endnotes

1. See for example Samuel Glasstone and Philip J. Dolan, eds., The Effects of Nuclear Weapons, 3rd edition (Washington, DC: USGPO, 1977) and earlier editions dating from 1950.

2. Personal communication with author, October 19-20, 2004.

3. Thom Shanker, "12 Million Could Die at Once in an India-Pakistan Nuclear War," New York Times, May 27, 2002; Elisabeth Bumiller and Thom Shanker, "Bush Presses Pakistan on Kashmir and Orders Rumsfeld to Region," New York Times, May 31, 2002; Todd S. Purdum with Seth Mydans, "U.S. Envoys Ready to Press Two Foes in Kashmir Crisis," New York Times, June 3, 2002.

4. An extended discussion of mass fire can be found in Lynn Eden, Whole World on Fire: Organizations, Knowledge, and Nuclear Weapons Devastation (Ithaca: Cornell University Press, 2004), chap. 1.

5. Eden, Whole World on Fire, p. 20.

6. See Eden, Whole World on Fire, chap. 1. Also, Gilbert Binninger, Roger Craver, and Suzanne Wright, Staff Officers' Guide for Targeting Uncertainties, DNA-TR-89-115, prepared for Director, Defense Nuclear Agency, Washington, DC (n.p., January 1990), p. 47, argues that range predictions for airblast under free-field conditions "can be in error by as much as ± 30%."

7. Ashton B. Carter, "Assessing Command System Vulnerability," in Carter, John D. Steinbruner, and Charles A. Zraket, eds., Managing Nuclear Operations (Washington, DC: Brookings Institution, 1987), pp. 561-563, 571-572. The specific targets of interest may be different today, but similar targets are to be found in urban and suburban areas. Regarding range of damage, see Binninger, Craver, and Wright, Staff Officers' Guide, p. ix, discussed in Eden, Whole World on Fire, p. 246.

8. Comments by H.L. Brode on the United States Strategic Bombing Survey (1947), September 2004, enclosed in Harold Brode letter to author, 30 September 2004.

9. Kistiakowsky quoted in Eden, Whole World on Fire, p. 1.

10. See the detailed narrative in Eden, Whole World on Fire, chaps. 9-10.

11. Eden, Whole World on Fire, chap. 10; personal communication, October 19-20, 2004.

Another View of the Role of Nuclear Power

Richard L. Garwin

I begin with a comment on a recent paper in P&S.[1] In their paper, the authors argue that U.S. energy problems would be largely solved by the deployment of "proliferation-resistant fast reactors". In support of this argument, they make a number of serious errors in their discussion of the utility of reactor-grade plutonium (R-G Pu) in the fabrication of nuclear explosives:

"... weapons made from R-G Pu have a yield that is highly unpredictable-- they would be very likely to 'fizzle,' producing no mushroom cloud at all." (p. 10.2.8)

"... even as a terrorist weapon that will definitely fizzle ..." (p. 10.2.8)