reconsidered in a decade in light of new technology and changed economic conditions, with the spent fuel cooler and much less radioactive. All options would still be open: (i) reprocessing of HLW, with extraction and recycling of valuable resources; (ii) deep burial of fuel assemblies; or (iii) better long-term disposal methods, including even international arrangements.

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Radiation Effects Research in Japan

The following three statements in Gina Kolata's 11 July News & Comment article about Chernobyl follow-up (p. 147) merit amplification or correction.

1) "The National Academy of Sciences . . . spends $10 million a year to follow 110,000 Japanese survivors. . . ." The $10 million represents about half the cost of the studies, the other half being provided by the Japanese government.

2) "The NRC studies, which are funded by [the Department of Energy] DOE, include annual health exams on 20,000 of these Japanese. . . ." As mentioned above, these studies are funded equally by DOE and the Japanese government acting through the Ministry of Health and Welfare. The examinations are conducted biennially, not annually.

3) "The studies . . . were, for many years, purely a U.S. undertaking. In the mid-1970's the Japanese began helping to fund the studies and Japanese investigators began participating." The early studies were initiated by the Atomic Bomb Casualty Commission (ABCC), a field agency of the National Academy of Sciences, with funds provided by the U.S. government. However, almost from the inception of the studies the Japanese government participated actively in the research. Two branch laboratories of the Japanese National Institute of Health were attached to ABCC in Hiroshima and Nagasaki, and the scientific and technical staff of these branches was completely integrated into the ABCC research. Since 1975, when the ABCC was reorganized into the Radiation Effects Research Foundation, equally funded by the United States and Japan, the staff from both countries continued the investigations begun about 40 years ago.

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Mobile Missiles

Not mentioned in R. Jeffrey Smith's three articles on mobile missiles (News & Comment, 6 June, p. 1186; 27 June, p. 1590; 22 Aug., p. 831) is the best-kept nonsecret of this Administration—the merits of housing a force of single-warhead Midgetman intercontinental ballistic missiles (ICBM's) in individual soft silos with 1-mile spacing in the existing Minuteman fields.

Very simply, a fleet of silo-based Midgetmen could be destroyed only by one nuclear explosion per silo within lethal range (closer than 200 meters). Since more than one attacking warhead must be launched to have one explode within range of a silo, the attacker disarms himself relatively in the attempt to destroy the silo-based Midgetman. Even if all the attacker's warheads were nominally capable of hard-target kill, it is generally assumed that at least two would have to be launched in order reliably to destroy a single silo.

Thus if the United States were committed to having about as many warheads as (for instance) the Soviet Union, and if half of these warheads were deployed in Midgetman silos, they would be essentially self-protecting.

The high prices usually quoted for a Midgetman force (typically $44 billion for 500 mobile Midgetmen) stem from that mobility and the technical uncertainties associated with hardened mobile launchers, together with the large requirements for staff for a mobile missile. Contractor studies for the Fletcher Committee in July 1983 indicated that a force of 1000 silo-based Midgetmen could be developed, procured, and operated for 10 years for some $11 billion—$11 million per deployed warhead. This includes, incidentally, making the Midgetman a fast-burn booster to evade boost-phase intercept of a potential defensive system.

The Midgetman should be developed and the first 450 deployed to replace the Minuteman II in current silos. At the same time, two contractors should be funded to demonstrate rapid silo-plunging capability, so that the United States could match any great spurt in Soviet warhead numbers by the deployment of many individual silos.

Since the Minuteman silos are on some 6-mile centers, the six Minuteman fields that hold 1,000 Minutemen could accommodate some 30,000 Midgetman silos. The command and control and communications for the Midgetman already exist for the Minuteman.

Why do the Air Force and Defense Department speak of $90 million per warhead for mobile Midgetmen and not $11 million per warhead for silo-based Midgetmen? Why does the Defense Science Board (DSB) Task Force on Small ICBM Modernization not even include (*1*) ordinary silo basing among the candidates? First, there is no technological challenge for a silo-based old-technology missile—only benefits for national security. Those who favor the deployment of the MX missile tend not to want early competition for it and don't mind if the only Midgetman proposals carry a high price tag. And some are more interested in perpetuating the myth of ICBM vulnerability as the touchstone for spending on strategic offense or defense than doing something about it.

Most, however, want perfect solutions—a means for deploying just a few more warheads that will be invulnerable. Whether or not we will ever be able to target for destruction mobile warheads in the Soviet Union, our more open society and more restricted operating area will make us uneasy, in my opinion, if we ever do rely on mobility for the security of land-based missiles.

As I testified to the President's Commission on Strategic Forces (*2*) and to the DSB Task Force (*3*), the Midgetman should be committed for rapid deployment in silos, and supplementary mobile basing should be considered only when a credible argument can be sustained that the mobile system will be cheaper than the silo-based system that will have been deployed by that time.

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REFERENCES

1. *Report of the Defense Science Board Task Force on Small Intercontinental Ballistic Missile Modernization* (Department of Defense, Washington, DC, 1986).
2. R. L. Garwin, "Presentation to the Commission on Strategic Forces" (unpublished transparencies), 27 January 1983.
3. ———, personal communication to J. M. Deutch, Chairman, Defense Science Board Task Force on Small Intercontinental Ballistic Missile Modernization, providing outline of R. L. Garwin's presentation, 17 November 1985.

Erratum: In the article "Detection of water vapor in Halley's comet" by M. J. Mumma *et al.* (20 June, p. 1523), conflicting numbers were given for the production rate of water on 22 December UT (observing period). The correct production rate is $\sim 6 \times 10^{28}$ molecules per second on that date. The discussion of rotational populations of ortho-H_2O (p. 1527) should have stated that collisional excitation of 1_{10} (not 1_{01}) seems unlikely. The correct citation for reference 22 is *Astrophys. J.* **276**, 782 (1984).

Erratum: In the briefing listing MacArthur Foundation winners (News & Comment, 1 Aug., p. 517), Caroline W. Bynum's affiliation should have been the University of Washington, not Yale University.