INTRODUCTION

NUCLEAR WARHEAD SAFETY AND THE CTB

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During 1990, with the end of the Cold War, nuclear-warhead safety became the US nuclear-weapon design laboratories' leading argument against a comprehensive test ban (CTB). This shift marks the third—and hopefully final—stage in this debate.

From about 1961 to 1978, the principal argument against a CTB was based on the theoretical possibility that, by "decoupling" low-yield nuclear explosions in huge underground caverns, the USSR might be able to reduce their seismic signals to a level where they would be difficult to distinguish from background events.[1] Enough uncertainty was created about the verifiability of a CTB to result in the 1963 Partial Test Ban Treaty not banning underground testing.

In 1978, after the Carter Administration—determined to overcome the verification problem with an apparently cooperative Soviet Union—had resumed negotiations on a CTB, the problem of maintaining warhead reliability without testing became the main argument against a test ban.[2] There were a number of rebuttals by former weapon designers—the most detailed being in a 1987 report requested by the chairmen of the US House Armed Services and Foreign Affairs committees and other members of Congress from Lawrence Livermore National Laboratory weapon physicist, Ray Kidder.[3] However, progress toward a CTB was held up for another decade.

In the spring of 1990, the warhead safety issue surfaced in public as a result of recommendations from the US nuclear-weapon laboratories that the SRAM-A short-range attack missile not be loaded onto bombers on runway alert and that urgent safety-related modifications be made in nuclear-artillery shells deployed in Europe.[4] In response, the House Armed Services Committee established its own expert advisory panel made up of three senior physicists: Sidney D. Drell of Stanford, a long-time high-level government adviser on technical and national security issues; John S. Foster Jr, a former director of the Lawrence Livermore National Laboratory; and Charles H. Townes of the University of California, Berkeley, and another long-time high-level government adviser on strategic weapon policy as recently as the

Reagan Administration. Drell chaired the panel. This group returned with its report in December 1990. Excerpts are reprinted below.[5]

The chairman of the House Foreign Affairs Committee and other pro-CTB members of Congress turned again to Ray Kidder for his advice as to the impact of the safety concerns on the requirements for nuclear testing. On 10 September 1990, Kidder responded with a preliminary assessment, which is also reprinted below.[6] Kidder is now engaged in a more detailed study, also in response to a request from a group of members of Congress.

The two reports differ in part because they were asked to address different issues: the Drell panel was asked to advise on warhead safety while Kidder was asked to advise about safety-related testing requirements. Kidder's conclusion on testing requirements is therefore explicit: "a modest number of nuclear tests [of] weapons currently under development," while the implications of the Drell report for testing must be inferred. The most troubling implications of the Drell panel report for those advocating a CTB by 1995,[7] is its recommendation that completely new "safety optimized designs...be studied aggressively." One example of such a design cited by their report would have the plutonium core of the warhead trigger kept in a hardened container separated from its high-explosive chemical implosion system until just before the warhead reached its target. The Kidder report warns, however, that developing such warheads "would be a major and protracted undertaking requiring a very large number of tests" and concludes that "the cost-benefit aspect of such an undertaking is questionable in view of both the performance penalties that would be paid and its strong adverse implications for nuclear arms control."

The Drell panel report does not discuss the arms-control implications of its recommendations. It appears to have been driven more by another concern: the "political consequences" if a nuclear-warhead accident resulted in a plutonium contamination incident. Apparently the panel feared that a plutonium-contamination accident might trigger a public rejection of nuclear deterrence similar to the rejection of nuclear power that occurred during the 1970s and 1980s.

The judgements of both reports as to "how safe is safe enough" were therefore affected to a considerable extent by political as well as technical judgements.

Aside from the disagreement over the value of "safety optimized designs," there appears to be little disagreement between the Drell panel and Kidder about the safety problems in the existing stockpile or the shorter-term improvements that could be made to mitigate them.

What are the safety concerns from nuclear-warhead accidents? In order of declining importance, they are the possibility of: a nuclear explosion with a significant yield, the widespread dispersal of a significant fraction of a warhead's plutonium in an aerosol of inhalable particles as a result of the accidental detonation of its chemical explosives,[8] and the contamination of a relatively small area with plutonium-containing ash as a result of a fire consuming a warhead nonexplosively.

An accident could cause a nuclear yield if it triggered the electrical arming, fuzing, and firing systems of the warhead. To protect against this possibility, both reports agree that the electrical systems of older US warheads should be brought up to modern standards. Kidder adds that this does not require nuclear testing.

Since 1968, it has also been an explicit design requirement for US nuclear weapons that there be no significant yield as a result of a detonation in the implosion mechanism beginning at a single point as a result of impact or fire. The unclassified version of the Drell panel report hints, however, that, as a result of recent three-dimensional hydrodynamic and neutronic calculations on supercomputers, it has been discovered that not all US nuclear warheads satisfy this "one point" safety requirement. Kidder's report indicates that the problem is with nuclear artillery shells. Because of their small diameter and other constraints, it is more difficult with nuclear artillery shells than with other warheads to achieve an effective implosion and the uncompressed core is therefore closer to a supercritical state.

Kidder notes, however, that warheads about whose nuclear safety there is concern can be rendered safe by "mechanical safing." An example of such mechanical safing might be to introduce a length of neutron-absorbing wire into the hollow interior of the plutonium core and withdraw it mechanically shortly before the warhead reaches its target. Kidder also notes that, with the reunification of Germany and the demise of the Warsaw Pact, it can be expected that US nuclear artillery shells will soon be in safe storage.

The problem of plutonium dispersal by an accidental detonation of the

chemical explosive in a nuclear warhead is dealt with in most modern nuclear warheads by using "insensitive high explosive" (IHE) in the implosion mechanism. The Drell panel notes, however, that, as of the beginning of 1990, only 25 percent of the US stockpile was equipped with IHE. Kidder points out that, aside from the warheads on the Minuteman ICBM and on submarine-launched ballistic missiles, all US warheads that do not contain IHE are expected to be retired. He also points out that it would be possible to substitute existing warhead designs that already contain IHE for the ballistic-missile warheads that do not. It would also probably be possible, if the military insisted, to design and test somewhat higher-yield replacement warheads containing IHE before 1995.

Both reports agree that the greatest danger of a plutonium-dispersal accident would be as a result of an airplane crash or fire. Indeed, the only two incidents with US warheads that have resulted in widespread plutonium contamination were crashes of nuclear-armed B-52s in 1966 and 1968. Since that time, the US Air Force has kept its nuclear-armed aircraft on the ground. However, the Drell panel points out that the Department of Defense—unlike the Department of Energy—continues to routinely transport non-IHE nuclear weapons by air. Kidder urges that all transport of nuclear weapons by air in peacetime be halted and that nuclear-armed alert aircraft not be stationed near operating runways.

The least serious potential consequence of a warhead accident would be local plutonium contamination event as a result of a warhead burning without exploding. As the Drell panel report points out, in contrast to an explosive plutonium dispersal accident, which could create a plutonium inhalation hazard over an area of hundreds of square kilometers, the area of contamination from a fire would be on the order of one square kilometer and and most of the plutonium-containing particles would be too large to be inhaled.

The Drell panel notes that some modern warheads contain "fire-resistant pits" that are designed to contain molten plutonium for the duration of a several-hour-long jet-fuel fire and panel recommends that all warheads loaded on aircraft be so equipped. Kidder's report does not take a position on this point. The warhead for the new short-range attack missile for US strategic bombers, the SRAM-II, does have a fire-resistant pit. If a decision were made soon to develop and test such designs for other aircraft-carried weapons by

1995, however, it could presumably be done.

Whether the warhead-safety issue delays a CTB beyond 1995 therefore depends upon whether it is necessary to go beyond well-understood technical fixes, such as improved electrical systems, insensitive high explosive and fire-resistant pits, to new "safety-optimized designs" where the weapon laboratories would be invited, in effect, to start again with a blank sheet of paper. Kidder does not think that this is necessary. The Drell panel is not so sure. The source of the difference seems to be that Kidder thinks that a CTB is an important arms-control policy objective, while the Drell panel did not directly address this question. Ultimately, however, this is a political decision and the US Congress and the Soviet government should face up to it with out undue delay.

NOTES AND REFERENCES

1. A.L. Latter, E.A. Martinelli, J. Mathews and W.G. McMilan, "A Method of Concealing Underground Nuclear Explosions," *Journal of Geophysical Research* **66** (1961), pp.943–946.

2. *Effects of a Comprehensive Test Ban Treaty on US National Security Interests*, Hearing before the Subcommittee on Intelligence and Military Applications of Nuclear Energy of the US House Committee on Armed Services (Washington DC: US Government Printing Office, 1978).

3. Ray E. Kidder, *Maintaining the US Stockpile of Nuclear Weapons During a Low-Threshold or Comprehensive Test Ban*, Lawrence Livermore National Laboratory Report, UCRL-53820, unclassified version, 1987.

4. *Department of Defense Authorization for Appropriations for Fiscal Year 1991*, Hearings before the Senate Armed Services Committee, 23 May 1990, pp.219–279.

5. Nuclear Weapons Safety, Report of the Panel on Nuclear Weapons Safety of the US House Committee on Armed Services (Washington DC: US Government Printing Office, 1990).

6. Ray E. Kidder, *Assessment of the Safety of US Nuclear Weapons & Related Nuclear Test Requirements*, 10 September 1990.

7. See, for example, *Toward a Comprehensive Nuclear Warhead Test Ban* (Washington DC: International Foundation, 1991).

8. See, for example, Steve Fetter and Frank von Hippel, "The Hazard from Plutonium Dispersal by Nuclear-warhead Accidents," *Science & Global Security* **2** (1990), pp.21–42.