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History of U.S. Nuclear Weapon Safety Assessment:

The Early Years

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Abstract

From the beginnings of the U.S. nuclear weapons program, military and civilian dual-agency judgment has been fundamental to achieving nuclear weapon and weapon system safety. This interaction was initiated by the Atomic Energy Act of 1946, which created the Atomic Energy Commission (AEC).¹ The principle of using dual-agency judgment has been perpetuated in the design and assessment of the weapon and weapon system acceptance process since that time. This fundamental approach is still used today in all phases of the weapon life. In this paper, an overview of the history and philosophy of the approach is described.

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¹ This was a civilian agency with broad responsibilities to acquire nuclear capabilities in weapons and to develop other nuclear energy capabilities. The AEC existed as a separate agency until 1974. From 1974 until 1977, there was a change in name from AEC to the Energy Research and Development Administration (ERDA). ERDA was changed in name to the Department of Energy (DOE) and made a cabinet-level department in 1977. While the name (and some functionality) changed, the basic responsibility for nuclear weapons remained unchanged.

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The Beginning: The Atomic Energy Act of 1946

In the post-World War II era following the development of nuclear weapons, the U.S. government formed the civilian Atomic Energy Commission (AEC) to be responsible for the development and control of all forms of nuclear energy, including nuclear weapons. One intent was to have the atomic energy and weapon programs under civilian control but with shared responsibilities between the AEC and the military. A key requirement of the law was to specify that ultimate control of nuclear weapons and special nuclear materials resides with the President. AEC responsibility for nuclear weapons included research, development, testing, production, and retirement. On behalf of the government, AEC was given ownership of weapons-grade nuclear material, and of facilities for nuclear material processing and weapon-associated production.² The AEC was also given the responsibility for assuring public safety during all phases of weapons production and use lifetime. In order to assure that dual-agency responsibilities were exercised, a joint DoD-AEC Military Liaison Committee (MLC) was established to serve in an advisory capacity for what was then the Department of War and the Navy.³ As an additional measure, a Director of Military Applications was appointed from within the military to serve in the AEC. A mechanism for resolving any disputes between the military and civilian agencies was also established. Arbitration was provided by the secretary of the military agency, who could refer matters to the U.S. President for final decision.⁴ This was a precedent-

² A unique feature is that all facilities are government owned, but contractor-operated.

³ This later became the Department of Defense, or DoD.

⁴ The current process can be arbitrated by the Nuclear Weapons Council (comprising senior DoD and DOE personnel), and any matters carried forward are conveyed jointly by the Secretaries of Defense and Energy, either to the President, or through the President's National Security Council.

setting structure that served as the beginnings of the U.S. dual-agency independent safety review approach.

Custody of the weapons was initially the responsibility of the AEC. In some situations, a separable nuclear capsule was the means of AEC control.⁵ Because of readiness and operational considerations, the custody of the weapons was transferred to the military at the beginning of the 1960s. The presidential national command structure retained control of the use of the weapons.⁶ However, the AEC-DoD joint responsibility for assessing the safety of the weapons in military custody was retained. The AEC laboratories most directly responsible for designing nuclear weapons (Sandia Corporation, Los Alamos Laboratory, and Lawrence Livermore Laboratory⁷) represented the AEC as designers of various safety approaches for weapons. A new weapon concept, known as a "sealed-pit" warhead, evolved. This concept permanently associated the nuclear material with the warhead high explosive and resulted in different approach to safety assessment.

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⁵ This configuration has not been used since the early 1950s.

⁶ Beginning in the early 1960s, this capability was enhanced by the implementation of "permissive action link" (PAL) control.

⁷ Now all three are designated as National Laboratories.

Requirements

In the late 1950s, a general government nuclear weapon policy was established to assure public safety. In part, it stated, "that nuclear weapons and nuclear weapon systems require special consideration because of their political and military importance, their destructive power, and the potential consequences of an accident or unauthorized act. They shall be protected against the risks and threats inherent in their environment. The search for increased weapon system safety shall be a continuous process beginning as early as possible in development, and continuing throughout the life cycle of a nuclear weapon system." These standards, formulated by the DoD with AEC(DOE) support,⁸ were:

1. There will be positive measures to prevent weapons involved in accidents or incidents or jettisoned weapons from producing a nuclear yield.
2. There will be positive measures to prevent deliberate arming, launching, firing, or releasing except upon execution of emergency war orders or when directed by competent authority.
3. There will be positive measures to prevent inadvertent arming, launching, firing, or releasing.

⁸ The AEC/DOE established a similar set of standards for manufacturing, assembly and disassembly, and for weapons in its custody.

4. There will be positive measures to insure adequate security.

A positive measure was defined as "a design feature, safety device, or procedure that exists solely or principally to provide nuclear safety." The basic standards remain in effect today with some changes in wording and are supported by both agencies.

Independent Review—Late 1950s, early 1960s

In the late 1950s, the US Air Force established a Nuclear Weapon System Safety Group (NWSSG) to provide independent review of weapon systems and the details of their operational handling, using the four standards as the review criteria. The other services followed suit shortly thereafter, and an AEC(DOE) member (advised by DOE laboratory advisors, e.g., Sandia Laboratories) was added to each. NWSSG responsibilities included verification that the standards were met using effective positive measures, and development of a set of Safety Rules for the deployment of the nuclear weapon system. These rules were specifically structured for each weapon system and approved by the Secretary of Defense with AEC(DOE) concurrence.

NWSSGs continue today and, in addition to reviewing the weapon system prior to deployment, conduct periodic operational reassessments after deployment. The reassessments occur two years from the first review, and every five years thereafter. Each review is intended to be a fresh look or "clean sheet" and examines the weapon system design and operation to assure that system changes, new environments, etc., have been

properly addressed. The NWSSG reviews are supplemented by other forms of DoD and DOE independent review

AEC(DOE) Field Reviews

The proposed set of Safety Rules, developed by an NWSSG for operation of the weapon system (e.g., aircraft and bomb, missile and re-entry vehicle) were sent up the military chain of command for review and approval. They were also sent to the AEC(DOE) for concurrence. The AEC(DOE) would independently review the proposed rules by conducting an AEC(DOE) Rules Review Study. This group, chaired by an individual from the AEC(DOE), included senior members from the National Laboratories (Los Alamos, Livermore, and Sandia). As part of the review, this group would go to the appropriate military field operational sites and observe the proposed safety rules in operation with trainer weapons. If the group concluded that these rules were satisfactory, the DoD was provided AEC(DOE) concurrence. The AEC(DOE) field reviews were required on all new systems and when significant modifications were proposed to an existing weapon system.

Quantitative Requirements

In the late 1960s, quantitative safety criteria were established for the weapons. These were specified in the Military Characteristics (MC) document. The MC also established other parameters of the weapon (yield, weight, reliability, etc.), and was supplemented by

a Stockpile-to-Target Sequence (STS) document specifying physical normal and abnormal (accident) environments. The MC was prepared in collaboration with the AEC(DOE), then formally transmitted to the AEC(DOE)-DoD Military Liaison Committee and safety requirements were specified for each weapon.

A uniform set of quantitative safety objectives was established for all programs.

Summarized, they stated that "the probability of a premature nuclear detonation of a warhead ... shall not exceed:

1. "Prior to launch, for the normal storage and operational environments described in the STS, 1 in 10^9 per nuclear weapon lifetime.
2. "Prior to launch, for the abnormal environments described in the STS, 1 in 10^6 per warhead exposure or accident."

These uniform weapon safety criteria maintained and reinforced the dual approach to nuclear detonation safety-- prevent accidents, but given an accident, prevent nuclear yield. The overall national risk was thus assured to be very, very low, but not solely dependent on accident prevention.

National Risk << (Accident Probability) \times (Probability of Nuclear Yield given an Accident)

More Independent Review

Design Review and Acceptance Groups (DRAAGs) are an independent entity of each service on behalf of the DoD. The DRAAG is an all-military review group, but has members from each of the Services with a nuclear weapon capability. DRAAGs review weapon designs prior to formally accepting the design as meeting the military characteristics on behalf of the DoD. Each was chaired by the military service that was principally responsible for the weapon (Army, Navy, or Air Force) with members from each of the other services, and accepted the weapon as being war reserve (WR). They conducted periodic reviews during the weapon development program and a final review of the design being proposed for deployment.

Personnel Security Requirements and Reviews

The two-person control concept was implemented at all AEC(DOE) and DoD facilities and operations in the late 1950s. Later, a Personal Assurance Program for screening critical AEC(DOE) personnel, and a similar Personnel Reliability Program for DoD personnel were also implemented. Both personnel programs include elements such as medical assessments and documentation of experience in nuclear explosives and weapons operations. Compliance to these requirements are reviewed and verified on a periodic basis. These programs are still an important part of assuring weapon system safety today.

Additional Safety Evaluation

In the late 1960s, a separate, independent organization was formed within Sandia to provide independent safety assessment of internally designed weapon safety features, and to provide an additional technical foundation for the safety assessment advice given to the AEC(DOE) in their independent review activities. Major emphasis was on evaluating abnormal environment (accident) safety technologies, both in improving the understanding of the accident environment and the response of weapon components exposed to the abnormal environments. The independence of the safety assessment organization was enhanced by establishing an organizational reporting level direct to high levels of management at Sandia and independent of the weapon design reporting chain. This action moved the independent nuclear weapons assessment into a new structure, which continues to be supported today.

During the early 1970s, significant improvements in safety technology were made by the three national laboratories. For example, Enhanced Nuclear Detonation Safety (ENDS) concept was developed at Sandia National Laboratories, and insensitive high explosives and fire resistant pits were developed and introduced by Los Alamos National Laboratory and Livermore National Laboratory. In the same time frame as these safety technology improvements, a joint AEC(DOE)-DoD reevaluation of the entire nuclear weapon system stockpile was conducted. One of the objectives was to assess the desirability of retrofitting with these new safety technologies. As a result of these reviews, safety

improvements were implemented as appropriate. These types of reviews have continued on a system-by-system basis.

Important Goals: Continuing Reviews; Continuous Improvement

This paper has provided only a brief overview of some of the major assessment interaction between the DOE and DoD. There are many additional elements to the total safety process conducted by the Department of Defense (DoD) and the Department of Energy (DOE). These elements include extensive internal assessment activities for the weapons and weapon systems. The DoD, DOE, and the National Weapon Laboratories continue to review existing systems and explore means of improving safety.

In reviewing the history of the U.S. nuclear weapons program, it is clear that independent assessment through a dual-agency structure, and through separate, internal independent assessment groups, such as exist at Sandia National Laboratories, has been a major contributor to the U.S. nuclear weapon safety record.

Acknowledgment

In summarizing my exposure to the history of U.S. nuclear weapons safety, I also drew on the experiences and writings of numerous other participants in the program. Since it is impractical to credit every source of information, the best I can do is acknowledge that there were a large number of people who contributed directly or indirectly to the information I have outlined.