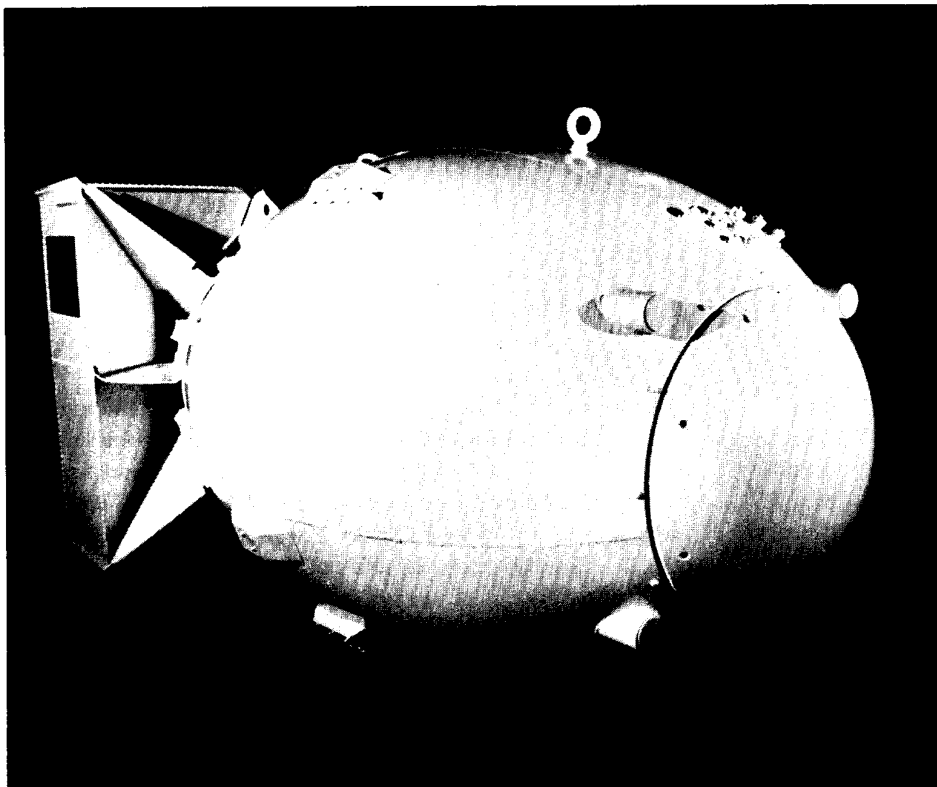

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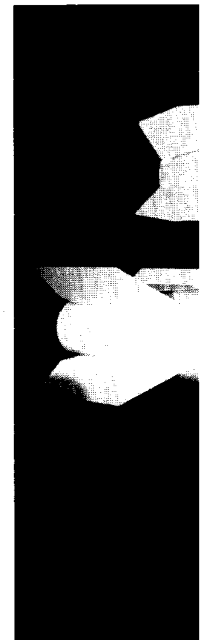

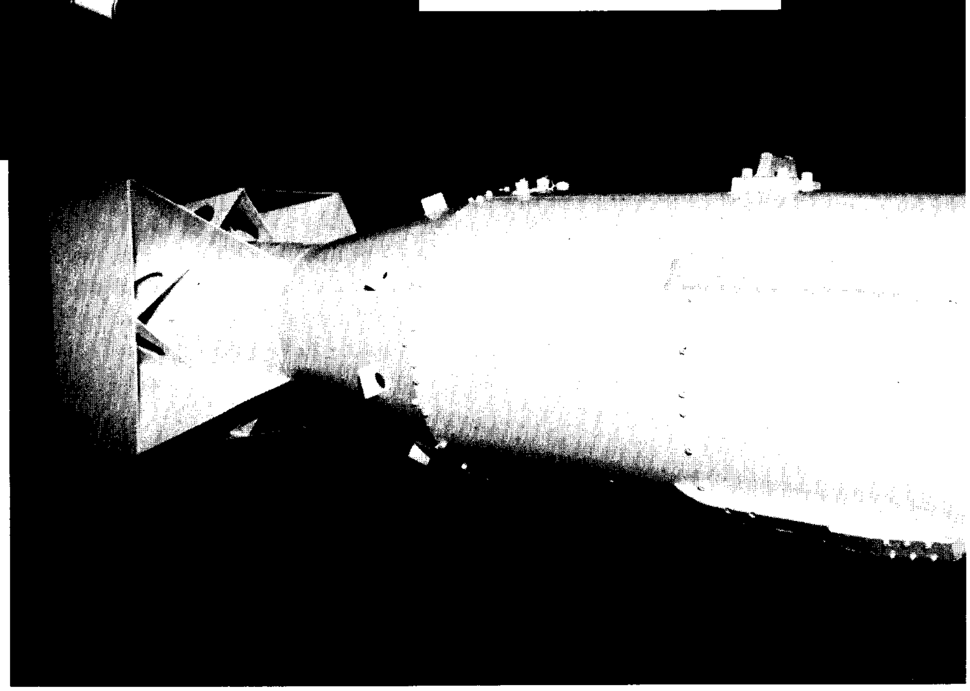

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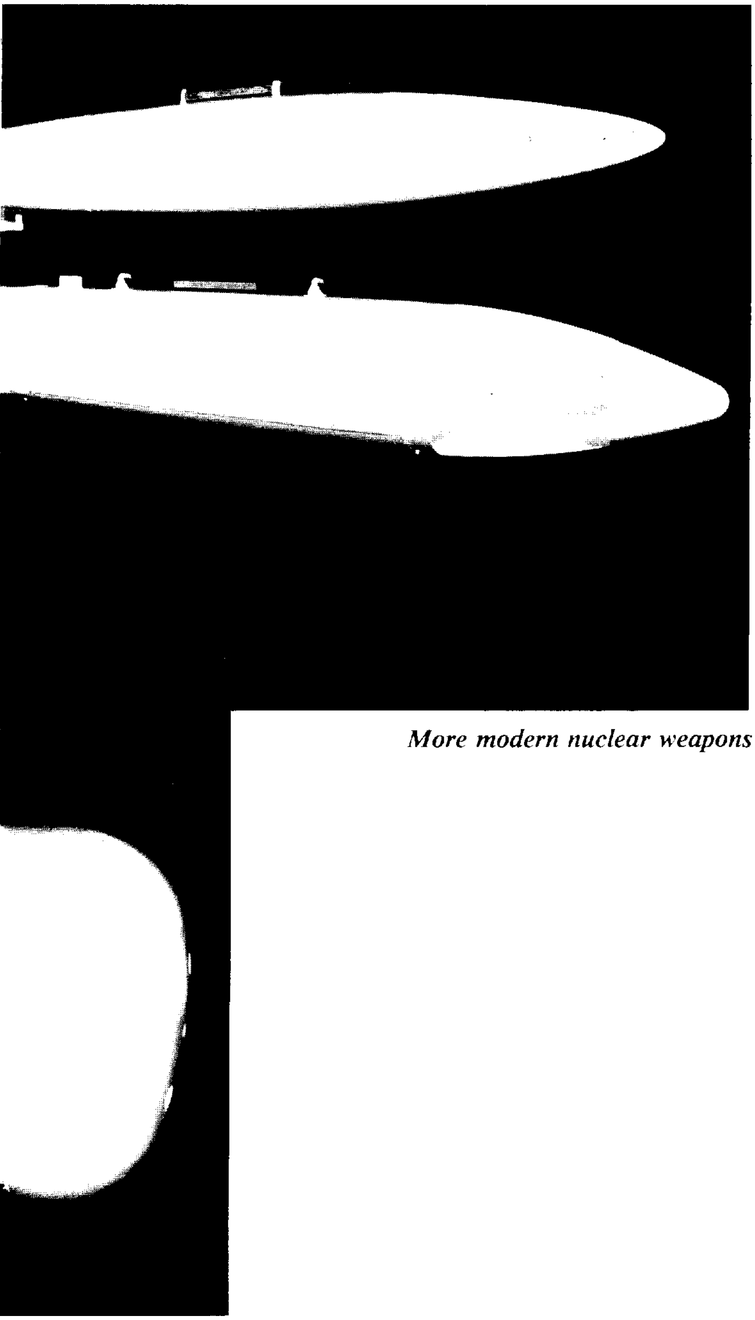
The Weapons



More modern nuclear weapons

Program

Overview

by C. Paul Robinson

The major mission of Los Alamos National Laboratory continues to be research and development of nuclear weapons. Having developed the first fission bomb as well as the first fusion bomb, the Laboratory continues as a center of excellence in the nation's most important defense science.

The fortieth anniversary of the Laboratory is synonymous with that of the nuclear weapons program, This anniversary is a significant event since normally a scientist's career—from receiving a Ph.D. at age 25 to retirement at 65—also spans forty years. Thus, with few exceptions the original pioneers in nuclear weapons have all completed their scientific careers and the weapons program is staffed by a new cast. Although the original sense of urgency has paled. the importance of the work has not, and today's weapons scientists and engineers are no less dedicated or purposeful than those of the first generation.

Over the past forty years the task of recruiting talented staff and maintaining a high sense of mission has not always been easy. The strict controls over nuclear secrets continue to be a fact of life. Very little substantive information has been declassified concerning the detailed physics and hydrodynamics of nuclear weapons. much less any of the design principles. Thus. the scientists and engineers who specialize in nuclear weapons research and development spend their entire careers working within a '-closed" technical society with little recognition of their work beyond that of close associates.

In society at large, opinions of the importance of weapons work have generally reflected the changing attitudes regarding the value of a strong national defense, attitudes that vary from pride in our nation's strength to the fear of war, particularly a nuclear war. In general, the relative isolation of Los Alamos has helped insulate the Laboratory and its weapons staff from the sometimes mercurial sentiments of the outside world. The importance of long-term stability in the weapons program cannot be overemphasized, both in allowing extremely complex problems to be attacked over a span of many, years and in providing a training ground for new scientists in complex subjects, some so difficult that only after a decade of work beyond the Ph.D. is one prepared to undertake original research.

The Laboratory has consistently enjoyed high respect and continued strong support from the political leaders of the nation in both Democratic and Republican administrations and from the Congress as a whole. The next few years should present an important test of national support as we see a grass-roots movement emerging to protest continued research and development of nuclear weapons. Most of' us within the nuclear weapons community welcome this inquiry by the public into the philosophy of nuclear defense matters and believe our role and stature will, in the long run. be strengthened by this attention. We believe the fundamental role of advanced technology in defending a democratic society must be re-examined and understood by each generation of Americans.

Major Research and Development Themes

in attempting to provide a snapshot of the nuclear weapons program on the occasion of its fortieth anniversary, it is useful to reflect on some of the important research and development themes of the last several years. This undertaking is difficult because of our tight security restrictions. (The only declassifications during the last few years involved concepts developed more than 25 years earlier.) However, discussion of a few themes should allow some insight into the overall scope of the effort.

Physics issues being investigated include two scientific mysteries dating from the early 1950s: "boost" physics and radiation flow. "Boost" refers to the process whereby thermonuclear reactions are used as a source of neutrons for inducing fissions at a much higher rate than can be achieved with neutrons from fission chain reactions alone. Achieving conditions for thermonuclear burn requires creating enormous temperatures (higher than within stars) simultaneously with enormous pressures. Since this process has no analogy within other realms of science, essentially all of the physics—including new mathematical methods—had to be created to provide theoretical understanding and design techniques. The science of nuclear weapon phenomena has always been a driving factor for larger and faster computers,* and boost physics will continue to require major advances in computing hardware, as well as in physical theory, before a complete description from first principles will be possible. This statement still is accurate in spite of the fact that today Los Alamos has what is believed to be the largest scientific computing center in the world.

The first megaton-yield explosives (hydrogen bombs) were based on the application of x rays produced by a primary nuclear device to compress and ignite a physically distinct secondary nuclear assembly. The process by which the time-varying radiation source is coupled to the secondary is referred to as radiation transport. Again, radiation fields of such magnitudes or characteristics had not been encountered in any other field of science, so the physical theories and methods had to be created, Similarly, full mathematical description is limited by the computing power of today's best scientific computers.

One of the most important research efforts to be initiated in the last decade is the inertial fusion program. Inertial fusion seeks to utilize laser radiation or ion beams to compress and heat fusion fuels to achieve thermonuclear reactions in the laboratory. Although directed toward different objectives, inertial fusion experiments embody significant aspects of radiation-transport physics. However, since the scale is significantly reduced, the physical characteristics of the processes and the resulting "micro-explosions" do not precisely replicate the phenomena exhibited in nuclear explosions. Nevertheless, the similarities have brought new approaches and techniques, and indeed new scientists, to explore these complex phenomena. The similarities have also brought strict control of the important inertial fusion information, and the major efforts in this field are carried out as classified projects within the weapon laboratories (Los Alamos, Livermore, and Sandia).

Classification restrictions allow little to be said about the modern practice of nuclear weapon design beyond the observation that, even after 40 years of quality research and development, improvements in both yield-to-weight and yield-to-volume ratios continue to be made.

The primary function of nuclear weapons is to provide strategic deterrence. Their ability to destroy essentially any blast-sensitive area target should deter all-out aggression by any adversary. In recent times efforts have also been devoted to developing nuclear weapons for tactical or military theater use in order to deter invasion by superior forces. Such uses would employ, if necessary, small nuclear warheads with outputs tailored to destroy the invading force with little collateral damage to nearby population. Los Alamos has played a major role in developing such munitions and continues to explore the potential for such weapon innovations. Another interest is exploration of possible uses of nuclear explosives as energy generators to power other specialized weapons. Energetic photons from a small nuclear explosion were used by Los Alamos scientists nine years ago to generate a short burst of laser light. Such exploratory research activities exemplify the frontier technologies being studied and evaluated within the nuclear weapons program today.

The Laboratory's engineering development activities have concentrated in recent years on improving the safety and security of nuclear weapons. Our most important design aim is to ensure that no nuclear explosion could ever occur in any conceivable accident. An enormous reservoir of human ingenuity and activity has been expended to meet this goal. In the autumn of 1980, a Los Alamos nuclear weapon, the Titan missile warhead, was involved in an accidental explosion of the rocket's fuel. Although the warhead itself was caught up in the explosion blast and was hurled, along with hundreds of tons of steel and concrete, more than 200 yards from the missile silo, the warhead survived essentially intact. The many safety features incorporated in the design served well. Neither that accident nor any other accident involving U.S. nuclear weapons has resulted in a nuclear explosion.

Los Alamos pioneered the development and use of insensitive high explosives in nuclear weapons. These unique chemical explosives provide greatly improved safety against even the spread of the radioactive materials in accidents ranging from airplane crashes and fuel tires to intentional firing of a rifle into the high explosive.

Other significant recent engineering developments include the "ruggedizing" of the devices to withstand extreme environments. An example of the hardness that can be achieved is a new earth-penetrating nuclear warhead that can survive ground impact and significant penetration without adverse consequences to its explosive capacity.

All advanced technology results from a blending of theory and experiment, and for nuclear weapons underground tests are the essential experimental ingredient of our research and development programs. We have adapted quite well to carrying out all of these

The first sizable computer, the ENIAC developed in the late '40s and early '50s and now displayed at the Smithsonian Institution, was used for nuclear weapon calculaions.

experiments deep underground in an isolated desert area in southern Nevada. Besides proof-testing new designs or alterations to previous designs, the Nevada tests sample and measure the unique conditions produced within a nuclear explosion. Very sophisticated instruments have been developed for such measurements. Detectors must register the physical phenomena and transmit the data to the surface before being enveloped in the nuclear fireball. Most of these diagnostic techniques have eventually found application in a variety of other scientific measurements.

Major Weaponization Programs

In recent years Los Alamos has been responsible for designing all new strategic warheads that have entered the nation's stockpile.

The W76 is the principal warhead for submarine-launched ballistic missiles, each carrying a number of independently targeted warheads. These warheads are carried on Poseidon and Trident submarines and represent one of our most important retaliatory nuclear forces.

The W78 is deployed on Minuteman III land-based strategic missiles.

The W80, a common warhead for both air- and sea-launched cruise missiles, represents a major development in strategic weaponry. These weapon systems do not pose a first-strike threat against potential adversaries but do guarantee that specific targets could be precisely attacked in a retaliatory strike. Cruise-missile weapon systems represent the best of America's advanced electronic guidance and targeting capabilities, augmented by exceptionally compact nuclear explosive charges. These systems should provide a major share of our deterrent capability for a decade or more.

In addition to these strategic systems, other Los Alamos weapons under development include warheads for the Navy's air-defense missile, the Standard Missile 2, and for the Army's Pershing II intermediate-range missile and significantly improved versions of the Air Force's and Navy's air-carried bombs.

Supporting Activities

A variety of other defense activities have arisen over the years, Most of these, such as providing concepts for protecting our re-entry vehicles, relate to the nuclear weapons mission. Fundamental questions, such as the degree of protection needed to survive high fluxes of neutrons or gamma rays, require both new theoretical and experimental techniques. Recently we have considered other threats, including laser and particle beam fluxes as well as electromagnetic pulses. These studies required the development of energy sources and damage measurement instrumentation, along with elaborate mathematical simulation models. This effort exemplifies a continuing characteristic of Los Alamos research efforts-that concentrated efforts can yield significant improvements in the state of the art on either side of an issue. Understanding the limiting features of hardening a strategic system against attack inevitably leads to improved concepts for the best methods to attack enemy systems.

Verification activities, particularly in regard to nuclear test treaties, have diversified and expanded. The Limited Test Ban Treaty of 1963, which precludes nuclear tests in the atmosphere, led to research into detection of nuclear explosions there or deep in space. Satellite-based instruments, along with ionospheric probes and detectors, have provided valuable data on the natural background conditions in space while continuously monitoring for nuclear explosions. In addition, we have developed seismic detection systems to provide higher accuracy in determining the yield of underground tests, which are limited under the threshold test ban treaty (observed although unratified) to less than 150 kilotons.

Two emergency operations teams have been formed to respond to accidents involving U.S. nuclear weapons or to threats of improvised nuclear devices. The value of highly skilled personnel on the scene during such crises cannot be overestimated. The teams comprise volunteers whose normal work assignments range from weapon design theorists and engineers to explosives experts.

Although the Laboratory has always devoted some effort to the development of nonnuclear weapons, we have expanded these activities in response to ever-widening threats. The subjects of improved lightweight armors and armor Penetrators have substantially benefited from our research and innovation. Laser and electromagnetic wave generators have been conceived and developed into prototypical devices. Similarly, we have utilized our expertise in particle accelerators to build prototypes of neutral particle beam weapons.

A recent innovation, which appears to have significant potential for a variety of defense missions, combines the scientific capabilities in accelerator and quantum optics technologies to create large free-electron laser systems.

Small but quite important defense-related projects now under way include defensive approaches against chemical and biological warfare attacks, particularly rapid detection and protection. We also have begun to explore technological responses to deal with terrorist or subnational threats.

Finally, we have undertaken a concentrated effort to identify the most serious technological threats we may encounter in the future. Thus, we are again emphasizing the most important long-range mission of the Laboratory: to determine how science and technology can best be employed to defend the country,

Although any projections regarding the course of weapons research and development during the next 40 years would be fraught with difficulty, I believe it safe to assert that warfare is likely to be far more chaotic in the future than in the past. We cannot rely on any single technology, not even our nuclear strength, to provide an absolute defense. We must continue to probe wide areas of science, both to prevent technological surprise by an enemy and to create new strengths for ourselves. ■