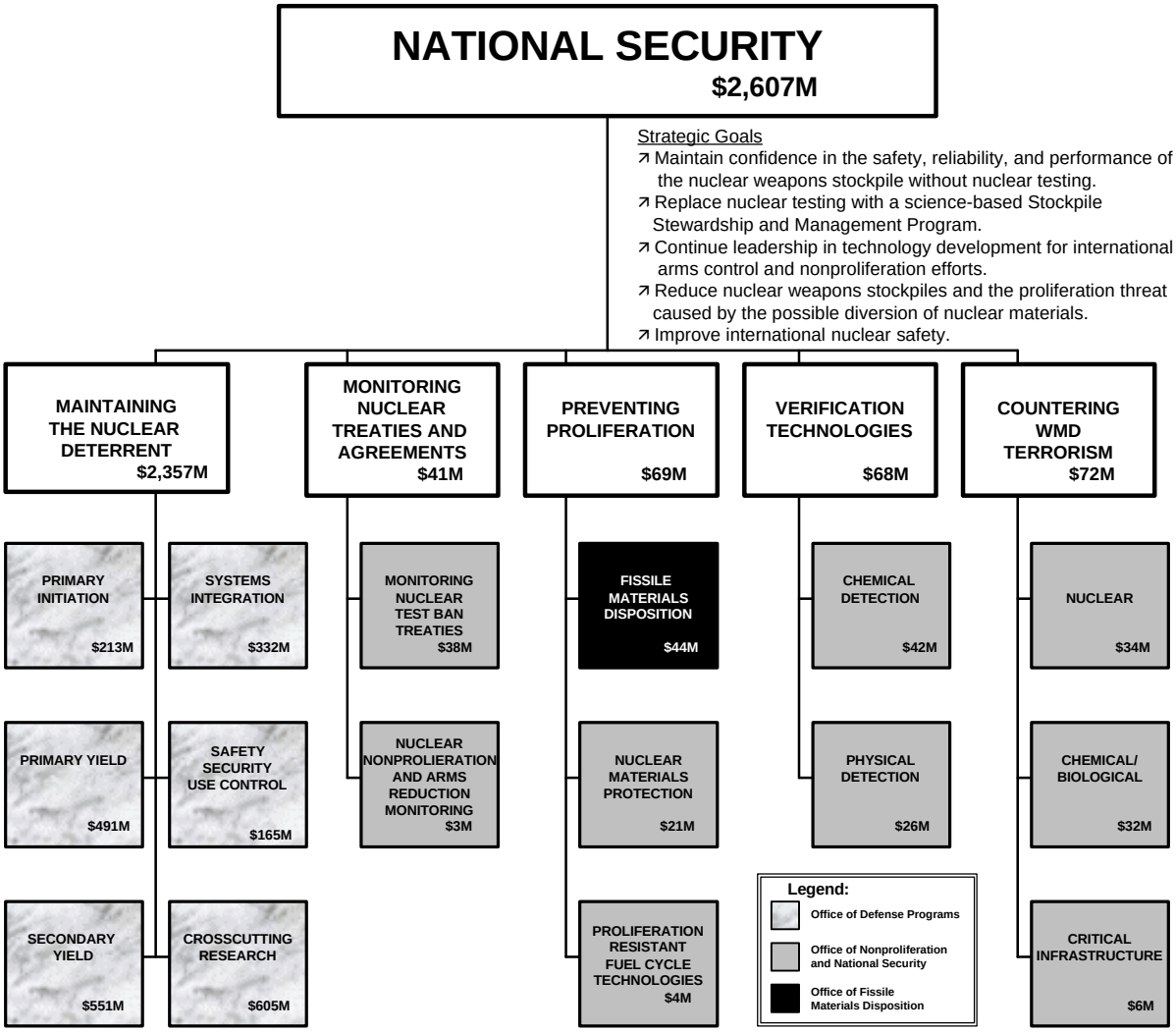
Chapter 1
Introduction



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Background

The Department of Energy has the national security mission of acting as responsible steward of the nation's nuclear weapons and reducing the global nuclear danger through its national security, nuclear safety, and nonproliferation activities. DOE is an integral member of the U.S. national security community and plays an essential role in the provision of unique technical expertise in support of the Department of Defense, the Department of State, and other agencies focused on reducing the global danger from nuclear weapons and other weapons of mass destruction.

The post Cold War national security environment is dangerous and increasingly complex. U.S. national security continues to require the maintenance of a safe, secure, and reliable stockpile of nuclear weapons. For over 50 years this has been – and continues to be – one of the core missions of the Department of Energy. The maintenance of the nuclear weapon stockpile is a primary deterrent to threats to the national interest.

> *"As a part of our national security strategy, the United States must and will retain strategic nuclear forces sufficient to deter any future hostile foreign leadership with access to strategic nuclear forces from acting against our vital interests and to convince it that seeking a nuclear advantage would be futile. In this regard, I consider the maintenance of a safe and reliable nuclear weapon stockpile to be a supreme national interest of the United States."*
>
> — President William J. Clinton

The Department is responsible for the safeguarding and security of all U.S. facilities at which nuclear weapons information, expertise, technologies, or material are available. The domestic mission includes reducing the number of sites where surplus weapons plutonium is stored, and disposing of surplus highly enriched uranium and plutonium.

Concerns over the proliferation of weapons of mass destruction have grown considerably in recent years. At least 20 countries are known to be or are suspected of developing weapons of mass destruction (WMD). This concern was underscored by the recent underground nuclear tests of India and Pakistan. The fragmentation of the Soviet Union has led to concerns about the accountability, control, and disposition of weapons, components, materials, and information. The threat that nuclear weapons or materials could fall into the wrong hands through theft or diversion is a clear and present danger. The increased activity and technical sophistication of non-state actors is a further concern.

The U.S. national security leadership has clearly stated that there is a close relationship between maintaining our national security and controlling the spread of weapons of mass destruction.

> *"The dangers we face are unprecedented in their complexity. Ethnic conflict and outlaw states threaten regional stability. Terrorism, drugs, organized crime, and proliferation of weapons of mass destruction are global concerns that transcend national boundaries and undermine economic stability in many countries."*
>
> —President William J. Clinton

> *"As the new millennium approaches, the United States faces a heightened prospect that regional aggressors, third-rate armies, terrorist cells, and even religious cults will wield disproportionate power by using – or even threatening to use – nuclear, biological, or chemical weapons against our troops in the field and our people at home."*
>
> —Secretary of Defense William S. Cohen

> *Those out to do us harm are no longer just political zealots with a few sticks of dynamite. These are determined operatives, with access to very sophisticated information and technology. Unable to confront or compete with the United States militarily, they try to achieve their policy objectives by exploiting small groups to do the dirty work for them.*
>
> —General John M. Shalikashvili, USA
> Chairman, Joint Chiefs of Staff

DOE has shifted its priorities over the past several years to reflect the new an evolving geopolitical military realities of the post Cold War world. To deal with the change, DOE has enhanced activities that advance U.S. nonproliferation policy while maintaining the viability of deterrence with a smaller, more agile, secure nuclear weapons complex.

Continual improvements to monitoring and verification capabilities both protects U.S. interests and enables global efforts to ensure that treaties are upheld. Verifiable treaties enhance world-wide interest in nonproliferation goals by reducing the danger to both nuclear and non-nuclear states.

In addition to its role in monitoring and verifying nuclear treaties, DOE has a major role in research and development to prevent the spread of nuclear weapons in other countries. DOE and its national laboratories are involved in providing international safeguards for foreign nuclear facilities, in supporting the entire range of International Atomic Energy (IAEA) activities, and in making sure that technologies related to nuclear materials and weapons are not deliberately or inadvertently transferred to countries of proliferation concern.

Verification technologies are an integral part of the U.S. national security strategy. These measures, designed to reduce existing military threats and prevent new ones from arising, are an essential complement to our military programs to respond to such threats, allowing the United States to maintain greater security at lower cost. Improved verification technologies enable us to focus on problems before they become crises.

DOE sponsors and is responsible for an extensive R&D program, most of which is carried out at the DOE national laboratories. DOE-sponsored R&D is focused on advancing applied, and sometimes basic research. Implementation is jointly planned with national security users at other agencies.

The DOE Research and Development Portfolio

DOE assembled its research and development portfolio recognizing the complexity of the U.S. national security challenge, and the requisite continuity implicit in DOE's current research activities, which in part reflect past and present Congressional and Executive guidance and intent. The Department also acknowledged in assembling its portfolio that the complexity and inter-relatedness of the U.S. Government national security establishment means research in any particular scientific or technological area may have direct as well as indirect effects on setting objectives for the national security research and development portfolio.

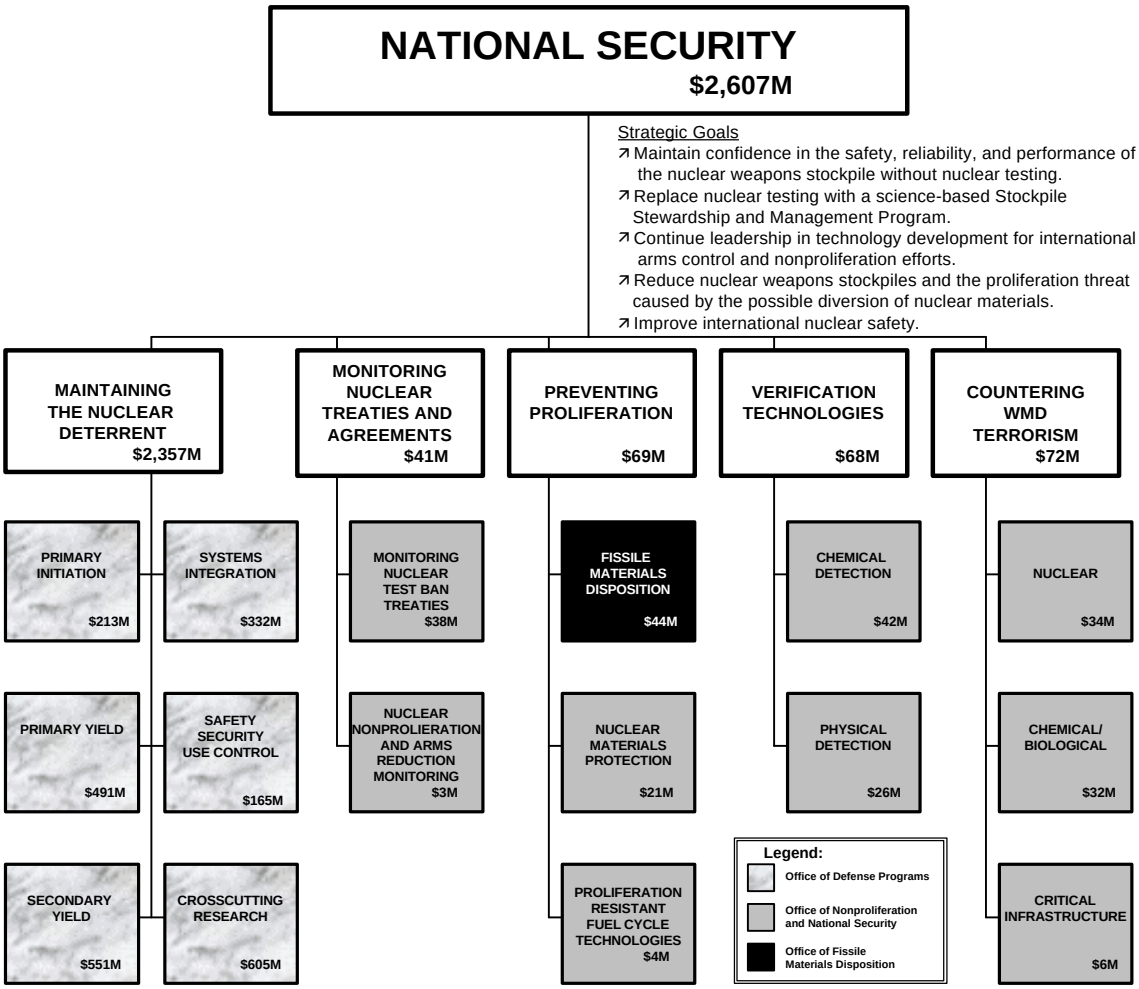
The DOE national security research and development portfolio has been structured into five primary activity areas that respond to DOE objectives:

- Maintaining the Nuclear Deterrent.
- Monitoring Nuclear Treaties and Agreements.
- Preventing Proliferation.
- Verification Technologies.
- Countering Weapons of Mass Destruction Terrorism.

Primary research and development efforts will be described in detail in Chapters 3 through 7.

The structure of the DOE National Security research and development portfolio and organizational responsibilities is shown on the following page.

National Security Research and Development



Maintaining the Nuclear Deterrent

Until the current cessation of testing in 1992, underground nuclear testing was the principal means to assure the performance of nuclear weapon systems and to benchmark design codes used in the assessment of nuclear weapon safety, reliability, and performance. In 1993 the President challenged the Department of Energy and the Department of Defense "to explore other means of maintaining our confidence in the safety, reliability and performance of our weapons." In the 1994 National Defense Authorization Act, the Congress directed the Secretary of Energy "to establish a stewardship program to ensure the preservation of the core intellectual and technical competencies of the United States in nuclear weapons."

Three particular challenges must be met:

- Fully supporting, at all times, the U.S. nuclear deterrent with safe, secure, reliable nuclear weapons.

- Preserving the core intellectual and technical competencies of the weapons laboratories. Without nuclear testing, confidence in the U.S. nuclear deterrent will rest with confidence in the competency of the people who must make the scientific and technical judgements related to safety and reliability.

- Ensuring that the activities needed to maintain the stockpile are coordinated and compatible with the nation's arms control and nonproliferation objectives.

Now, confidence in the stockpile must be maintained by using an improved set of scientific and engineering tools. To meet this challenge new facilities are being established to measure physical phenomena occurring in weapons or scientifically scalable to those occurring in weapons. Examples include: the behavior of plutonium; the evolution of material, including fusion burn, when suddenly, it is converted to plasma and compressed by high temperature radiation at extreme pressures; the effects of aging, radiation and neutrons on the electro-mechanical performance of weapon control systems. New or upgraded facilities for this research include: the Dual Axis Radiographic Hydro Test (DARHT); the National Ignition Facility (NIF); the OMEGA laser at University of Rochester; the ATLAS and Z pulsed power facilities; the Los Alamos Neutron Science Center (LANSCE); gas guns; and the U1a complex at the Nevada Test Site. Computer simulations will be relied on to an unprecedented extent to predict the complete end-to-end performance of the weapons and to design and interpret the experiments that reveal behavior of selected phenomena. The development of computer simulation models to extrapolate system performance from underlying physical models is a primary objective of the Department's national security research and development program. Methodologies must be developed to assess the impact of aging and manufacturing defects and changes, among other scientific and engineering challenges.

Monitoring Nuclear Treaties and Agreements

The goal of this program area is to develop technologies and systems, and the attendant scientific basis thereof, to enable detection, characterization, and attribution of nuclear treaty violations with sufficient timeliness and confidence to permit effective national and international treaty verification. The current focus is largely on development of a robust capability to monitor the Comprehensive Nuclear-Test-Ban Treaty (CTBT), when it enters into force. However, the underlying conditions that shape U.S. monitoring requirements will remain in effect, whether or not official entry into force of CTBT ever occurs.

Preventing Proliferation

United States policy is to seek to eliminate, where possible, accumulation of stockpiles of highly enriched uranium and plutonium, and to ensure that where these materials already exist they are

subject to the highest standards of safety, security, and international accountability. DOE is committed to safely dispose of the nuclear material made surplus by the downsizing of the nuclear arsenal in conformance with arms control and nonproliferation treaty requirements. Disposition strategies include immobilizing plutonium in a ceramic matrix and surrounding it by high-level waste and 'burning' plutonium as mixed-oxide (MOX) fuel in commercial U.S. reactors. The research and development portfolio in the area of preventing proliferation addresses completing the necessary process development and technology tests that will provide the design and operational basis for facilities that can disposition surplus plutonium.

The threat that nuclear weapons or materials could fall into the wrong hands through theft or diversion is a clear and present danger. Nuclear materials such as plutonium and highly enriched uranium are highly valued by potential proliferators. The danger exists not only in the potential for proliferation of nuclear weapons, but also in the potential for environmental, safety, and health consequences, if surplus fissile materials are not properly managed. This situation is made more complicated by the dissolution of the Soviet Union, and the political and economic turmoil currently affecting Russia. The development of technologies and systems to monitor, protect, and account for nuclear materials must keep pace with the increasingly sophisticated efforts of smugglers to move such material, or thieves to remove them from safe keeping in sites throughout Russia and other countries

To reduce the danger of nuclear weapons proliferation, the Department of Energy supports the Reduced Enrichment for Research and Test Reactors (RERTR) program. One of RERTR's most important and successful activities has been the development of low enriched uranium (LEU) fuels to permit conversion of research reactors from high enriched uranium (HEU) fuel to LEU.

Verification Technologies

Proliferating nations go to great lengths to conceal their proliferation activities and take other actions to prevent their detection. We are constantly faced with new and demanding technical problems that need to be solved. Efforts to stem proliferation activity rely upon remote sensing and other technologies, for which numerous technical challenges remain. Primary challenges facing the developers of new systems include: designing a system that will overcome deception and denial efforts, all weather and day/night operation, improved measurement accuracy, and providing new detection techniques not possible with existing state-of-the-art sensors. The development of verification technologies sensors will continue to be a top priority, so that timely information can be provided to policy makers with sufficient notification to allow the U.S. to intercede early in the proliferation cycle before national security is significantly compromised.

Countering Weapons of Mass Destruction Terrorism

While deterring terrorism is not new to DOE (which sustains a modest Nuclear Emergency Search Team program within its Stockpile Stewardship and Management Program), the breadth of the WMD terrorism problem and its overlap with nonproliferation programs is much greater than before the dissolution of the Soviet Union. This program builds upon ongoing activities in other agencies, and addresses specific scientific and technical areas in which DOE has unique

expertise. There are three primary activity areas: nuclear material detection, including the development and demonstration of nuclear radiation detection sensor systems to deter nuclear smuggling activities as well as to enhance nuclear material accountability and control; chemical/biological detection, including the development and demonstration of capabilities to detect the presence of chemical and biological materials and agents, to enhance biologic forensics tools and understanding, and to counter or remediate the presence of such weapons; and critical infrastructure protection, including cyber security improvements to ensure DOE's information security.

Role and Relationship with Technology Partners

DOE or its predecessor agencies have developed and supplied all of the nation's nuclear weapons. The Los Alamos National Laboratory and the Lawrence Livermore National Laboratory were originally established to design nuclear weapons and the Sandia National Laboratories to design and develop sophisticated engineering control systems for those weapons. These missions remain the principal focus of these three DOE laboratories which constitute the core of research and development to maintain the stockpile. The Nevada Test Site, where about 1000 weapon tests have occurred, is maintained ready for tests, should it become necessary as a supreme national interest, and at the same time provides technical support to the laboratories as well as the capability to expend plutonium in scientific, non-nuclear, studies. Other DOE laboratories as well as universities and industry provide basic science and engineering support to the weapons laboratories.

Because of the increased reliance on science in maintaining our nuclear deterrent, the contribution of the nation's science infrastructure is of increased value. Atomic physics, nuclear physics, plasma physics, chemistry, engineering science, and materials science that can be applied to Stockpile Stewardship are supported by other components of DOE and by other agencies as well as by industry and universities. The weapons laboratories conduct the research and development to apply all of these sciences to analyzing and maintaining the stockpile and in their efforts they contribute to the scientific infrastructure and increasingly engage with the larger national community of science and technology developers. Through DOE's Advanced Strategic Computing Initiative, high energy density physics programs, and direct contracts by the weapons laboratories, universities conduct over $75 million dollars of research annually funded from Defense Programs for its value in maintaining the nuclear deterrent. The weapons laboratories engage in cooperative research and development with industry where DOE's capabilities can contribute to national interests.

The Department of Defense (DoD) shares responsibility with DOE for maintaining the nuclear weapon stockpile. The requirements for the stockpile are stated in the Nuclear Weapons Stockpile Plan which is developed annually by DOE and DoD and is approved by the President. The DoD sets military requirements, jointly manages test flights of weapon systems, participates in planning for surveillance of the stockpile, and participates in certification and refurbishment of weapons. The DoD relies on DOE capabilities, including the Nevada Test Site, and provides some personnel resources to DOE in planning and management activities.

DOE or its predecessor agencies have been charged with providing the technologies and systems needed for the United States to monitor the compliance with nuclear test treaties for over 35 years. Requirements to enable treaty monitoring as established by the Department of Defense (DoD) and the Intelligence Community (IC) drive the development of sensor technology for detecting nuclear explosions conducted underground, underwater, in the atmosphere, and in space. They also specify the needs for data management and analysis tools to process and correlate the enormous amounts of data produced by these sensor systems.

DoD requirements for sensor and data systems to support their nuclear warfighting mission (specifically Nuclear Force Management and Integrated Tactical Warning and Attack Assessment) significantly overlap atmospheric and space treaty monitoring requirements. Accordingly, our satellite-based sensor systems are designed to address both missions. DoD provides the funding for the deployment and operation of these systems.

Congress directed that the Department be responsible for all activities relating to the management, storage, and disposition of fissile materials from weapons and weapons systems that are surplus to the national security needs of the United States. DOE executes R&D activities associated with the disposition of surplus plutonium through the expertise and facilities provided by the national laboratories, universities, and, in some instances, industry.

Success in developing new capabilities to detect proliferation will require an end-to-end approach, with detailed attention to the range of alternative proliferation paths, the phenomenology of the collection technology, and the interplay of potential new forms of technical data with other existing sources of information in assessing a target activity. In partnership with the Intelligence Community and the Department of Defense, DOE provides end-to-end system concepts for new technical approaches which can augment our national capabilities, along with technical risk mitigation through the development and field demonstration of prototype systems. DOE's partnerships with these agencies are facilitated through Memoranda of Agreement (MOA).

The Department of Energy has unique roles because of its nuclear weapon responsibilities, and the DOE laboratories are uniquely qualified to meet these national challenges. The production of weapons-quality fissile material is the greatest challenge faced by a would-be nuclear state. In many instances technologies developed to remotely monitor the proliferation of weapons of mass destruction also are well suited to support other important national needs. DOE's national laboratories feature unique assets in sensor technology development. Furthermore, efforts that address the detection of biological and chemical agents for counterproliferation, force protection, and anti-terrorist applications can be spun off and will be supported.

Presidential Decision Directives have established a role for the Department of Energy in addressing nuclear terrorism. This is an element of the total WMD terrorism picture and complements the responsibilities of other agencies. The DOE and its Laboratories have a history of working with others to address this problem in a structured way so that national technology investments will yield the greatest result.

Deterring and responding to chemical and biological terrorism presents formidable technological challenges. The chemical and biological nonproliferation R&D capitalizes on an annual DOE R&D investment of over $1B in relevant chemical and biological sciences. Through close coordination with other agencies, the Department provides applications-oriented direction to the Laboratories performing R&D in areas such as detection, modeling and prediction, decontamination, and biological forensics. The Laboratories' efforts are coordinated with each other and with R&D programs supported by other agencies.

The R&D in its early phases is generally executed at the DOE national laboratories. DOE is sensitive not only to requirements from those agencies which must use its technology but also to the opportunities to partner with companies which ultimately produce much of the equipment DOE develops.