# Alternative Futures

for the
Department of Energy
National Laboratories

**Prepared by the**
**Secretary Of Energy Advisory Board**

***Task Force on Alternative Futures for the***
***Department of Energy National Laboratories***

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Idaho National Engineering Laboratory
Lawrence Berkeley Laboratory
Lawrence Livermore National Laboratory
National Renewable Energy Laboratory
Los Alamos National Laboratory
Sandia National Laboratories
Argonne National Laboratory
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# Task Force on Alternative Futures for the DOE National Laboratories

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# I.Overview

## A. Introduction

This Task Force was asked to propose alternate futures for the Department of Energy laboratories noted in Figure 1(see inside front cover). The Task Force Charter is provided in Appendix C. Our intensive ten months' study revealed multiple missions and sub-missions -- traditional missions and new missions -- programs and projects -- each with factors of merit. Each iteration of our study would nevertheless still confound even the members of the Department and laboratory community, as evidenced by the oft-quoted statement: the laboratories, and indeed the Department, require a clearer, more focused statement of mission! . Our sorting of these matters has led us to a synthesis which when first revealed may appear too simple, too limiting or even too much of a play on words. But we respectfully suggest that this synthesis identifies an

essence -- the essence of what the Department, and particularly the laboratories, should and do stand for: the energy agenda.

Virtually everything the laboratories do is energy. The original laboratories' first assignment was a nuclear energy bomb -- developing the fuel, storing and containing the energy, and releasing the energy. More laboratories were formed and/or augmented in response to other energy needs which occasionally were identified as crises. Newer laboratories have credentials (among other credentials) for conservation and renewable energy. Most of the laboratories are concerned and resourced to deal with the various effluents of energy and its applications vis-a-vis the environment. The aggregate of science and technology competencies of the laboratories has served, and continues to serve, as one essential resource for the study of energy. At many given points in time energy is the paramount issue in our lives. A blackout in a nearby neighborhood or industrial plant is always headline news. Long lines of vehicles responding to (infrequent) fuel shortages capture everyone's self-interest. Although we are privileged to more often take energy availability for granted in the United States, we still press for longer battery life for our cellular phones and worry that some day we will run out of petroleum. Energy is so central to the vitality of our dynamic country that it has to be a priority concern as an ongoing national strategic issue. It may be legitimately referred to as an issue of importance to our general long-term national security.

**Our working definition of Energy is: Energy is power capable of doing work. The Physical, Chemical, and Biological Sciences which are used to derive fuels from natural resources are in turn enabled by Energy. Conventional energy sources include wood, water, oil, gas, coal, and nuclear fuels. The growing U.S. and world population requires all these, as well as new source such as solar energy, biomass, and wind energy. All must be made clean, safe, less expensive, and in the aggregate, abundant. Energy may be sourced centrally, locally, or portably. It must be generated, transformed, distributed, and properly utilized from all these sources. Future sources may include, for example, hydrogen, which is abundant in water, gas, and biomass; albeit a challenge to extract and store. DOE laboratory scientists have decades of experience with hydrogen and other basic sources. Their multidisciplinary competencies hold the promise of solving many such challenges.**

As we were in the latter stages of writing this report, occasional speculation surfaced concerning the continuing role of the Department of Energy, and suggesting in part that energy is not all that important. Such major agency structure issues are beyond our purview, but we do feel justified in asserting that the energy agenda which we will profile in this report does require central, federal, senior cognizance and appropriate government sponsorship in the interest of the short-term and long-term overall quality of life in America and the world. We will shortly make the point that the laboratories are essential (with appropriate changes, of course) in these regards. The laboratories we studied require a strong federal financial support and linkage or sponsorship, at least for a goodly number of years, for reasons that will be evident throughout this report. The Department can serve this role, appropriately redefined, well.

Returning to the subject of mission, we find ourselves comfortable with a mission whose meaning is bound up in serving energy opportunities. We introduce the thought with words that are not capitalized because we do not want to presume to capture as graphic art an all-encompassing meaning in a few short words. Nor do we believe that the Department or laboratories have been adequately served by articulating virtual slogans in

some of its noble efforts at projecting its purposes. Yet, even if one flashes the message Serving the Energy Opportunities on the proverbial screen, in its own quiet way it conveys what almost every other existing mission or program or project intended.

Let us narrow in on the word energy and its meaning. The word serves as the remarkable root word for defining mission(s) within a progressive parameter. At one and the same time, it gives focus and gives a wide-ranging field of relevant explorations.

Elsewhere in this report one will find our recommendation of need for focus -- a parameter of sorts to the roles of the laboratories. Yet it is not inconsistent that simultaneously we recommend the laboratories must be free to renew and press the frontiers in all relevant affordable ways in behalf of their energy agenda, broadly defined.

The rest of the world has an energy agenda of sorts as well. This agenda is to -- obtain for their people access to energy supplies comparable in all respects to -- those we now enjoy. This global energy agenda represents a huge opportunity for the U. S. energy industries. It also represents a competitive threat to those industries if they have not prepared and committed first to serve the right product. Finally, it represents a threat to our country and other countries if some nations employ technologies for energy production and usage which increase global pollution levels. Our purveyors to those expanding producing and using societies must be prepared to offer better. While serving the needs of our country with the leading edge of technology, we can best serve the needs of other countries, both environmentally and commercially, when we support them with technologies derived or derivable by the laboratories. All these self-evident contributions from the laboratories are in addition to the national security, defense and weapons stewardship role that gave birth to the first laboratories. This latter role will be a continuing irrevocable obligation for a minimum of two score more years.

The laboratories' research role is a part of an essential, fundamental cornerstone for continuing leadership by the United States. We know that the studies and discoveries of science unravel the elements of nature and shower benefits on mankind. We know by intelligent estimates that there is much more to be learned and shared. We know that these scientific revelations will unfold from many sources: a brilliant insight by an individual, a research team at a university, a corporate or government laboratory -- by accident, or on purpose. We know progress is hastened where diversity of personnel and institutions is encouraged.

We note that many of the least exploited investigative paths involve the need for extraordinarily sophisticated multidisciplinary teams using sophisticated instruments and tools. It is that role for which the national laboratories are uniquely qualified. It is the case for -- the justification of -- the existence of the DOE laboratories.

Yet most citizens do not know enough about the laboratories. We do not know the thousands of insights, new directions, new phenomena, new principles, materials and processes that blanket these laboratories' science spectrum, all relevant to an energy agenda. Examples include the world's most intense X-ray sources; biomedical isotopes; chlorofluorocarbon substitutes; computer models of combustion for cleaner energy; laser isotope separation; lasers for pollution monitoring; neutron sources to probe materials and biological systems; the unraveling of the puzzles of the human genetic code; the harnessing of the wind, sun and earth for renewable energy; superconductivity; global ocean and atmospheric studies; detection and tracking of nuclear materials; fossil, fission, fusion energy; novel semiconductor materials and devices; laser destruction of blood clots;

bioremediation of radioactive and hazardous waste; accelerator technology for medical applications; and remediation of radioactive storage tanks. These are but a few examples.

We are inclined to typecast these institutions simplistically by a few prominent contributions such as yesterday's bomb or the discovery of an element on the periodic table (both grand achievements), but overlook the multitude of other continuing achievements. We must reach out to know enough of this vast spectrum of accomplishments to justify our deserved support of these institutions that have contributed, are contributing, and will in the future contribute vital knowledge while continuing to revitalize themselves -- just as science always renews itself. We must be in quest of that which we do not know in the field of science in every relevant way. Each revelation will enrich us manyfold. The laboratories we review here are essential to the fulfillment of our need to know.

Under the overarching energy agenda -- the labs serving the energy opportunities -- we will comment on their national security role, the all important energy role, all related environmental roles, the science and engineering underpinning for all the above, a focused economic role, and conclude with governance / organization change recommendations.

**B. Missions of the National Laboratories**

The Task Force believes that a change of governance of the national laboratories is necessary regardless of the missions of these multi-program institutions. However, we also have strong views regarding the appropriate mission activities for the laboratories. One general observation of the Task Force is that the national laboratories, and the Department, appear to believe that they have the potential to serve an extraordinarily broad role in scientific investigation and technical research for the nation. The Task Force does not support this view. Rather, we see the laboratories as having clear areas of expertise, yet limited to their traditional mission areas of national security, energy, and environmental science and technology, as well as in the fields of fundamental science which underpin these missions and in basic science associated with high energy, nuclear, and condensed matter physics.

While the Task Force supports innovative application of the national laboratories' core technical competencies (for example, high performance computation, advanced materials, energy technologies, and systems engineering) to new problem areas, these activities should be carefully managed, are not likely to evolve into new missions *per se*, and should not be a license to expand into areas of science and technology which already are being addressed effectively or more appropriately by other Research and Development (R&D) performers in government, academia and the private sector.

The Task Force does believe that the national laboratories serve a distinctive role in conducting long-term, often high-risk R&D, frequently through the utilization of

capital-intensive facilities which are beyond the financial reach of industry and academia, and generally through the application of multidisciplinary teams of scientists and engineers. We believe that an appropriate division of labor among the national laboratories, industrial research institutions, and research universities can be established but does not sufficiently now exist.

The Task Force concluded that the work of these laboratories contributes in an important, though generalized fashion to the security interests of the nation, when security is defined broadly to include factors such as:

-Developing technologies which enhance the ability of the nation to deter and defend against military threats, to reduce the nuclear danger, and enhance confidence in our own nuclear weapons in the absence of explosive testing;

-Enhancing the prospect for sound patterns of energy use through the development of diverse, efficient, and sustainable energy technologies;

-Reducing environmental threats posed by the waste legacy of the nuclear weapons program and by the careful utilization of energy and materials throughout the economy; and,

-Expanding the base of scientific information -- which is one of the nation's greatest long-term strategic assets -- through pioneering work in a number of areas of fundamental science mostly related to the energy agenda.

One general observation about the missions of the laboratories is that the Task Force found it ironic that these institutions seem to be searching so hard for new missions when there remains a compelling agenda of important work to be performed in their traditional mission areas. The Task Force believes:

-The existing budget of the national laboratory system exceeds that required to perform its agenda in the areas of national security, energy, environment, and fundamental science;

-It is unrealistic for these institutions to attempt to retain their current size by laying claim to new missions; and,

-The urgent requirement for these laboratories is to provide more disciplined focus on the new research needs within the traditional set of mission areas, as described below.

Later we identify savings through reorganization which can be variously used to reduce budget, redeploy resources, and increase research in appropriate areas.

### 1. National Security

The primary national security mission of the DOE laboratories is to provide for a safe, secure and reliable nuclear stockpile in the absence of explosive testing of nuclear weapons. Continued scientific, engineering, and managerial excellence will be required at the laboratories to meet the complex and demanding stewardship role. A vital extension of this mission involves work in non-proliferation, counter-proliferation, arms control verification, and intelligence support. Another critical and daunting national security task for which the weapons laboratories have special expertise involves the safe tracking and disposition of fissionable materials.

### 2. Energy

The primary mission for the laboratories in relation to energy technologies is to pursue a research and technology development agenda which enhances the long-term prospects for adequate energy supplies and efficient end use technologies which minimize adverse environmental impacts. The primary role for the laboratories should be in areas where long-term research holds the prospect for significant payoffs, and where a clear public purpose is being served through Federal support. To the maximum extent possible, energy R&D at the laboratories should be coordinated with the private sector and be guided by technology road maps.

### 3. Environmental Science and Technology

The Department faces a monumental task in dealing with the radioactive and hazardous wastes at its former nuclear weapons production sites and national laboratories. This task cannot be addressed in an affordable fashion using today's technologies. The national laboratories have expertise and untapped potential which could accelerate the scientific and technological base which is urgently needed for the cleanup mission.

The laboratories also have significant contributions to make in research and development related to more efficient utilization of energy and materials, such as pollution prevention and waste minimization techniques, and also in areas associated with the environmental impacts of energy use, as in global climate

modeling. The Task Force believes that the laboratories have areas of demonstrated expertise that could provide the basis for an expanded mission in environmental research and technology development, but such expansion should occur only in areas where the laboratories have a comparative advantage to other R&D performers in academia, industry, or other government agencies.

### 4. Fundamental Science

The national laboratories have a major mission to serve in contributing to the scientific foundation which underpins the Department's other mission areas: national security, energy, and the environment. The laboratories also have important responsibilities in certain discrete areas of science for which mission applications are not immediately apparent - such as in high energy, nuclear, and condensed matter physics - but where contributions to the nation's scientific enterprise have been significant.

Such contributions often have derived from large-scale scientific user facilities that have been built and operated at the national laboratories (as well as at the Department's program-dedicated laboratories). Such facilities have enabled government, academic, and industrial researchers to explore scientific frontiers that have not been accessible in other ways. Long-term, fundamental research of this form has been part of the national endeavor to create a better future through investments which could have a transforming, yet unknowable impact on society. The Department should sustain and strengthen its support of fundamental science.

### 5. Industrial Technologies

Development of technologies for which private sector companies are the major beneficiary is not an appropriate mission for the national laboratories. Rather, the economic impact of R&D performed for such general benefit by the national laboratories should be viewed as a derivative, or outcome, of the other core missions. Collaborations between the national laboratories and the private sector serve the important function of providing dual benefits to the partners, but such collaborations generally should be closely aligned with core mission areas of the Department. To the extent appropriate, such collaborations should be cost-shared and tied to technology road maps developed by and with industrial sectors.

## C. Laboratory Governance

Our study revealed a counterproductive federal system of operation (Department, Contractor, Laboratory and substantially driven by Congressional policies). A far-less-federal system must be authorized by the Congress, adopted by the Department and implemented at the laboratories, possibly involving contractors. Certain far-less-federal systems promise large productivity gains with attendant major economies along with refreshed motivation by empowerment of the laboratory's greatest assets -- its devoted professionals. We urge embracing such a new concept promptly, adopting one or more new configurations early, and moving into a perfectible system apace, much as many non-federal institutions are doing with rich rewards.

The Task Force observed multiple symptoms of institutional stress at the national laboratories, including the following:

-Increasing overhead cost, poor morale and gross inefficiencies as a result of overly prescriptive Congressional management and excessive oversight by the Department;

-Inordinate internal focus at every level of these laboratories on compliance issues and questions of management processes, which takes a major toll on research performance;

-Excessive scrambling by the laboratories to establish programmatic activities in new mission areas, at the expense of disciplined focus on traditional assignments in national security, energy, waste management and environmental quality, and fundamental science;

-Confusion regarding the appropriate character, scope, and scale of laboratory collaborations with the private sector, due to a lack of clear policy guidance from the Department;

-Institutional fragmentation as a direct reflection of segmented management of the laboratories by the Department, which treats the laboratories not as integrated institutions -- let alone a system of laboratories -- but rather as a conglomerate of hundreds of individual projects, each of which has a program manager with independent influence on elements of the laboratories;

-Financial and institutional burdens on the laboratories as the result of an apparent inability by the Department either to downsize facilities which have excess capacity or to terminate programs which provide neither distinctive nor essential contributions to the national research and development enterprise; and,

-Management systems at the laboratories that do not exhibit best business practices, and thus compound the management challenges of these complex institutions.

The Task Force recognizes that many of the Department's laboratories are considered to provide some of the highest quality R&D among the federal laboratory system. With this understanding, the Task Force had the option of simply concluding that the problems facing the national laboratories were simply a fact of life of federal governance and that little more could be expected. The Task Force has no comfort with such an assessment, feels that it is reasonable, and indeed necessary to have much higher expectations for performance from these institutions, and believes that incremental solutions will not likely provide the major improvements that are, at once, achievable and necessary.

We arrived at this conclusion recognizing that conventional wisdom likely would provide a range of reasons why establishing a new system of governance for the laboratories might be impractical or jeopardize these assets. In our view, however, the long-term quality and effectiveness of these laboratories already is in serious jeopardy, owing to patterns of management and organization that have grown in complexity, cost, and intrusiveness over a long period. For those who have been long time employees, managers, or observers of the national laboratory system, perhaps it is easy to rationalize that the system in place is simply the way it is and the way it always will be. For those without lengthy associations with the Department or its laboratories -- which was the case for a majority of the Task Force members -- it is hard to reach any conclusion other than that the current system of governance of these laboratories is broken and should be replaced with a bold alternative. The Task Force seeks not to be bold for boldness sake, but because it believes that a far more effective system of governance is necessary.

While this report provides a general description for a not-for-profit framework for governance of the laboratories, we do not presume to know what the precise alternative architecture should be. That can and should be developed by Congress, the Department, and the laboratories, based on experience gained from existing research institutions which receive substantial funding support from the Federal Government, but which have an independent management structure which makes the decisions on how best to deliver the services which the Government is procuring. Insight also should be gained from the experiences of other nations, including the United Kingdom, which recently has maneuvered a disengagement of several of its government laboratories into a semi-privatized status.

A major experiment implementing wholly new management practices for the national laboratories does invite risks, and certain hazards must be recognized and guarded against within any implementing legislation. For example:

-Those national laboratories that work on nuclear weapons programs may not be appropriate candidates for transfer to a non-federal governance structure, especially given the need for continued stringent controls on all aspects of nuclear weapons design activities. Some Task Force members think they are. Some think they are not.

-The proposal to introduce a bold new paradigm for governance of these institutions must not be used as a political pretext to dismantle or destroy a system of laboratories which has served the nation well in the past, are continuing to perform important public functions, and holds the prospect for delivering new scientific insights and technological innovations which will justify its continued value to the Nation.

-Protection must be built into the governance structure to ensure that these institutions continue to perform long-term, fundamental research -- which is among their most distinctive contributions to the nation -- and not be driven to a short-term focus characteristic of job shops for the private sector. This goal could be reached through prescribed allocations which provide an inviolate base of federal funding support for certain critical areas of fundamental research and their associated large research facilities.

-It will be necessary to ensure that the change in governance is structured in a fashion to achieve the desired results, and that the new system not be burdened by creeping micromanagement, non-productive oversight, and institutional fragmentation which characterizes the present state of affairs at the national laboratories.

-A balance must be achieved between the need for necessary continuing oversight and reduction of environmental damage on the one hand, and the need for avoiding overwhelming the new organizations with excessive burdens and inherited environmental responsibilities on the other hand.

## D. Configuration of the Laboratories

The Task Force believes that the national laboratory system is oversized for its current mission assignments. This appears to be the result of inefficiencies that stem from the current management practices of the laboratories and the DOE; excess capacity in areas associated with nuclear weapons design and development; and political considerations which have inhibited downsizing and laboratory restructuring. The Task Force believes that the national laboratory system serves many vital functions, but that the system could be productively

downsized (or rightsized ) through the elimination of functions and redundancies. The Task Force further believes that one goal of any downsizing should be enhanced focus on specific mission assignments. Through downsizing, there may be opportunities in the future to convert one or more multi-program laboratories into institutions dedicated to only one primary mission.

The Task Force strongly believes that the laboratories should work more closely as a system, with the goal of achieving enhanced coordination and integration of complementary strengths. However, we note that such coordination will be made more difficult to the extent that the laboratories are separated into independently operated not-for-profit organizations.

While the Task Force does not make any recommendations about the possible closure of specific laboratories, we have a general view that all of the national laboratories should be subjected to a regular process of comparative validation against other research performers (including against each other) to judge options for closure, consolidation, and even expansion of programmatic activities and facilities. The Task Force believes that an alternative structure of governance for the laboratories that achieves greater independence of the laboratories from the Department would invite enhanced pressures for competitive performance, which would lower costs, force the elimination of redundancies and less than world-class capabilities, and achieve enhanced value for the public investments involved.

## II.The National Security Role

### A. Introduction and Background

#### 1. The Changing Environment

The Department of Energy's national security mission is based on the Manhattan Project, the development of nuclear weapons during and following World War II. The legacy includes independent design capabilities, redundant design teams, competition, and intense efforts to achieve the highest standards of safety, surety and reliability. The three weapons laboratories -- Lawrence Livermore, Los Alamos, and Sandia National Laboratories -- have evolved over a period of more than fifty years. It is clear that they played a key part in the successful outcome of the nuclear standoff with the former Soviet Union. For this, the entire nation owes a debt of gratitude to the women and men of these laboratories, past and present, who gave their talent to this successful endeavor.

The end of the Cold War has brought substantial change. Weapons modernization, arms control agreements, the fear of proliferation of weapons of mass destruction, and the significant decline in defense spending require a restructuring of the laboratories' support for the national security mission. Today, these laboratories represent an extraordinary national resource of people, facilities, and experience. Every attempt should be made to use this resource as missions change.

#### 2. National Security Requirements

The requirements for the DOE and the weapons laboratories are based on Presidential direction as approved in the Nuclear Stockpile Document and other Presidential Decision Directives. Congress provides direction in laws and committee reports. The Department of Defense (DOD) determines specific weapons requirements and the Department of Energy determines how to fulfill those requirements. The weapons laboratories then are assigned specific responsibilities and funding to carry out DOE direction.[1]

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[1]The weapons laboratories are Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LAND), and Sandia National Laboratories (SNL). LLNL and LAND are weapons design laboratories while SNL is the engineering laboratory.

The President stated in the National Security Strategy (July 1994) that a safe, secure and reliable U.S. nuclear deterrent remains a cornerstone of U.S. national security policy. The President announced a moratorium on underground nuclear testing with a goal of establishing a comprehensive test ban. He instructed the DoD and DOE to explore means other than nuclear testing to maintain confidence in the safety, reliability and performance of the weapons stockpile. He also directed strong efforts to support the Non-Proliferation Treaty and counter weapons of mass destruction. This direction is the basis for DOE and DoD planning for the future and the Task Force's consideration of alternate futures for the weapons laboratories.

The maintenance of a safe, secure, and reliable stockpile, contributions to critical proliferation and treaty issues, and participation in other national priorities related to this mission are essential parts of the nuclear weapons laboratories' future and require adequate facilities, motivated and capable people, and the requisite budget. This future will require new types of management, different technical personnel, and a mode of operation that is closer to industry's than the laboratories have practiced in the past.

### 3. Specific Weapons Requirements

The Department of Defense conducted a Nuclear Posture Review[1], approved by the President, to determine future nuclear forces and weapons requirements. Implementation of the START I and START II protocols will result in a total nuclear weapons reduction of 79% by the year 2003. As a unilateral action (Presidential Nuclear Initiatives I and II), the U.S. will reduce by 90% non-strategic nuclear weapons. These steps will result in a required stockpile of around 5000 weapons.

The Nuclear Posture Review identified the need for flexibility either to accelerate the drawdown if both sides implement START II more quickly, or the ability to return inactive weapons to service if the Russians suspend or delay START II implementation. The weapons laboratories need the capability to respond to either circumstance.

Over the past two years, the Department of Energy has established the Science-Based Stockpile Stewardship Program, replacing a test-based stockpile stewardship, to maintain confidence in nuclear weapons without nuclear testing. The focus of the new program includes improving experimental capabilities,

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[1]Brigadier General Anthony Tolin, USAF, Strategy and Policy, Joint Staff, private briefing on the Nuclear Posture to the National Security Subgroup of the Task Force, October 14, 1994.

enhancing computational capabilities, advanced stockpile surveillance, advanced manufacturing and materials capability, maintaining system engineering and infrastructure and preserving a nuclear design and experimentation capabilities.

## B. Main Findings and Recommendations

Specific recommendations regarding the future of the weapons laboratories fall into broad categories of mission, key personnel, configuration, peer review, basic science, research facilities, and weapon production (including research, production, tritium, and management). The Task Force believes that these recommendations are consistent with Presidential Directives,[2] the Nuclear Policy Review, and the Science-based Stockpile Stewardship Program.

### 1. Mission

The national security mission of the weapons laboratories has been rearticulated to emphasize maintaining credibility in the U.S. nuclear stockpile in the absence of explosive testing of nuclear weapons. The primary mission of the weapons laboratories must be a safe, secure, and reliable stockpile. Science-based stockpile stewardship (in comparison to a test-based stockpile program) is the approach chosen by the Department of Energy to achieve this mission. It requires the following rank-order priorities for the core functions of stockpile stewardship as follows:

1. Attracting and retaining skilled scientists, engineers, and managers over the years ahead with the expertise required for the complex and demanding stewardship role;

[2]Steven Andreasen, Strategic and Nuclear Affairs, National Security Council, private briefing on Presidential Decision Directives to the National Security Subgroup of the Task Force, August 9, 1994.

2. Enhancing surveillance of weapons in the stockpile[1], during dismantlement, and of the nuclear materials that accumulate as a result of that dismantlement;

3. Continuing hydrodynamic testing as required to cope with problems;

4. Assessing problems, reanalyzing previous data through numerical simulations, and developing appropriate data bases; and

5. Sustaining the scientific process of inquiry through experimentation.

In today's world, proliferation of nuclear and other weapons of mass destruction remains a major threat to U.S. national security. Because of this threat the DOE laboratories' work in non-proliferation, counter-proliferation, verification, and intelligence support has become a major mission as well as an extension of their stewardship of the nuclear stockpile. These activities are supported by the expertise maintained within the entire nuclear weapons infrastructure. It is important that their funding be included within the core infrastructure support. The Task Force notes that organizational compartmentalization within the Department complicates and makes difficult the appropriate inter-relationship and funding balance between stockpile support and non-proliferation, and recommends that the Department's organization reflect their importance and interdependence.

## 2. Attracting and Retaining Scientists, Engineers, and Managers

The weapons laboratories' management has an important responsibility to identify the critical skills required for their national security mission and to manage the hiring and retention of key personnel accordingly. The Task Force recommends that management continue to sustain a stimulating intellectual environment that will attract and retain the very best research and engineering staff. This will require:

-Providing appropriate rewards for high performers;

-Weeding out weaker performers; and,

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[1]Current weapons designs are secure, safe and reliable. There is no threat to the nation that would justify the development of a new nuclear weapon at this time. If weapons in the stockpile should develop problems that cannot be resolved, and that raise doubts about their reliability or safety, consideration could be given to the option of replacing them with modernized versions of earlier, very robust, well-tested designs. However, the safety and reliability record of the stockpile indicates the successful resolution of all past weapons problems; any future reliability or safety problems should be first analyzed and solved -- if possible -- by the replacement of specific components or addition of new safety features if needed.

-Engendering in the research and engineering staff a sense of achievement, based on personal responsibility and personal accountability.

### 3. Configuration of the Nuclear Weapons Laboratories

The current structure of the three nuclear weapons laboratories should be examined in light of the recently revised, official U.S. Nuclear Posture. The Department of Energy should size its nuclear weapons laboratories support efforts over time to match DoD requirements. The restructuring must be accomplished in ways that preserve capabilities both for reduction to lower levels of support and for an expansion of support should the resumption of a threat to national security demand it. In addition, the restructuring must support the requirement to maintain confidence in the nuclear stockpile in a comprehensive test ban or under an extended moratorium. The restructuring will affect primarily weapons design capabilities, where the largest functional redundancy exists, and specifically Lawrence Livermore National Laboratory (LLNL); LLNL supports only four of eleven weapons designs currently in the U.S. stockpile.

The Task Force believes LLNL should retain enough nuclear weapons design competence and technology base to continue its activities in non-proliferation, counter-proliferation, intelligence support, and verification, to provide independent review for several years while alternative approaches to peer review are developed (see Peer Review ), and to participate in weapons relevant experiments on the National Ignition Facility (NIF). LLNL would transfer, as cost-efficiency allows, over the next five years its activities in nuclear materials development and production to the other design laboratory. LLNL would transfer direct stockpile support to the other weapons laboratories as the requirements of science-based stockpile stewardship, support of the DoD nuclear posture, and the status of test bans allow. Under these conditions, the Task Force believes that the transfer can be made in five years. The Task Force notes that if the NIF is built at LLNL, this will reinforce the weapons design capability at that laboratory.

### 4. Peer Review

The Task Force believes that the development of independent assessment of the safety and reliability issues within an aging stockpile will be an ongoing requirement of stockpile stewardship. It also believes, however, that there are many ways in which this peer review function can be served, and that peer review, in and of itself, does not justify the existence of two nuclear design laboratories.

### 5. Contributions to Basic Science

As new facilities are developed at the weapons laboratories for performing science-based stockpile stewardship, the Task Force recommends that these facilities be managed in as open and collaborative a fashion as national security constraints will permit.

### 6. Major Research Facilities

The Task Force recommends the following:[1]

-Continued funding support for the Dual-Axis Radiographic Hydrodynamic Testing (DARHT) facility;

-Continued near-term support for Los Alamos Neutron Scattering Experiment/Los Alamos Meson Physics Facility (LANSCE/LAMPF);

-Continued pursuit of advanced computing, including computing through workstation networks; and,

-Proceeding with the National Ignition Facility (NIF) as a research facility, prioritized with respect to other major research investments.

In its favor, NIF will provide a unique means for doing very important experiments involving extremely high temperatures in condensed matter physics and it thus will make it possible to maintain expertise in one of the areas of physics fundamental to modern nuclear weapons design. Similarly, the data and theory it will produce will contribute uniquely to science generally and to astrophysics in particular. On the other hand, there is some possibility that NIF will inadequately simulate secondaries, although this is already a lower priority than understanding primaries. There is a low probability that inertial fusion will become a useful source of energy in the foreseeable future. NIF may not attract the scientists and engineers that stockpile stewardship really needs. NIF may also complicate discussions at the Non-Proliferation Treaty review conference and negotiations of a Comprehensive Test Ban Treaty. In short, NIF is a risk (as are most major research projects), but on balance the Task Force supports its construction. An important consideration is that the question of whether or not NIF is built at LLNL, when combined with other recommendations for change given in this report and elsewhere that could define the future of that laboratory.

### 7. Non-Nuclear Research Requirements



[1]The Jason Stewardship report entitled Science Based Stockpile Stewardship, August 10, 1994.

The Task Force recommends that non-nuclear research activities continue at the weapons laboratories as long as a paying customer requires them, as they are rooted in nuclear weapons research, contribute to core R&D, and pay their fair share of overhead and basic research support.

### 8. Nuclear Weapons Production Capacity

There is no need for nuclear weapons production at this time nor is start-up of production envisioned for problems expected in the stockpile. Capability-based deterrence requires, however, the potential for weapons production in the event of increased threat that may arise in the future. The current world situation and the existing production capability do not mandate investment in additional production capability. The Task Force recommends that future production should be based on the residual capabilities of Pantex, Los Alamos National Laboratory, and Sandia National Laboratories, and believes that no further investments in production capability are needed at this time.

### 9. Tritium Supply

Accelerator-based production of tritium looks attractive, given today's understanding of the technology. The Task Force, however, does not make a recommendation relative to replacement, or to the mode of production, but rather supports continued R&D in accelerator-based production of tritium.

### 10. Management of the Nuclear Weapons Laboratories by DOD

As requirements for national security change, DoD and DOE must size their organizations and improve their coordination for maximum effectiveness. The DoD must act as an intelligent and prudent customer regarding nuclear weapons. The separation, within the U.S. government, of nuclear weapons development and operations is a long tradition and has recently been challenged in the interest of efficiency. The Task Force, however, agreeing with most previous studies of this issue, sees no compelling reason for DoD to manage the national security activities at the weapons laboratories. Indeed, the Task Force believes that there is much value at this time in maintaining an independent and technically expert organization to focus on nuclear stockpile issues and to continue to ensure that decisions regarding the safety, control, and stewardship of nuclear weapons are raised to the high policy level that they deserve. The corporatization proposal contained in Section VII in the Task Force report could eliminate the management

issues for both DoD and DOE and give a customer focus to the weapons programs.

## C. Summary of Recommendations

*1. The primary mission of the weapons laboratories must be a safe, secure and reliable nuclear stockpile in the absence of explosive testing. Science-based stockpile stewardship is the approach chosen be the Department to achieve this mission. It requires the following rank-order priorities:*

- Attracting and retaining skilled scientists, engineers, and managers over the years ahead with the expertise required for the complex and changing stewardship role;

- Enhancing surveillance of weapons in the stock pile, during dismantlement, and of the nuclear materials that accumulate as a result of the dismantlement;

- Continuing hydrodynamic testing to cope with problems;

- Assessing problems, reanalyzing previous data through numerical simulations, and developing appropriate data bases; and

- Sustaining the scientific process of inquiry through experimentation.

*2. Non-proliferation, counter-proliferation, verification, and intelligence support have become a major mission along with stewardship of the nuclear stockpile. The Task Force notes that organizational compartmentalization within the Department complicates and makes difficult the appropriate inter-relationship and funding balance between support and non-proliferation, and recommends that the Department's organization reflect their importance and interdependence.*

*3. The Task Force believes Lawrence Livermore National Laboratory should retain enough nuclear weapons design competence and technology base to continue its activities in non-proliferation, counter-proliferation, verification, an intelligence support, to provide independent review for several years while alternative approaches to peer review are developed, and to participate in weapons relevant experiments on the National Ignition Facility (NIF). Lawrence Livermore National Laboratory would transfer as cost-efficiency allows over the next five years its activities in nuclear materials development and production to the other design laboratory. Lawrence Livermore National Laboratory would transfer direct stockpile support to the other weapons laboratories as the requirements of*

*science-based stockpile stewardship, support of the DoD nuclear posture, and the status of the test bans allow.*

*4. The Task Force recommends continued funding support for the Dual-Axis Radiographic Hydrodynamic Testing (DARHT) facility; continued near-term support for the Los Alamos Neutron Scattering Experiment/Los Alamos Meson Physics Facility (LANSCE/LAMPF); continued pursuit of advanced computing, including computing through workstation networks; and proceeding with the National Ignition Facility (NIF) as a research facility, balanced with respect to other major investments.*

*5. The Task Force recommends that future production needs should be based on residual capabilities of Pantex, Los Alamos National Laboratory, and Sandia National Laboratories, and believes that no further investments in production capability are needed at this time.*

## III.The Energy, Environment, and Related Sciences and Engineering Role

### A. Main Findings

This section of the report reviews the laboratories' energy and environmental roles (minus activities associated with clean-up of waste sites, which are dealt with in Section IV), and includes the Task Force's general observations about missions of the laboratories.

#### 1. The Energy Mission of the Laboratories

The national laboratories have an important energy mission which, in the view of the Task Force, remains absolutely vital to the national security and economic welfare of the nation. This mission started with the efforts to create peaceful uses of nuclear energy (a major goal of the civilian Atomic Energy Commission) and assumed new direction and urgency as a result of the energy crises of the 1970s. The 1973 oil embargo prompted Congress the following year to create the Energy Research and Development Administration (ERDA), folding together nuclear programs from the Atomic Energy Commission (AEC), fossil energy and utility distribution programs from the Interior Department, solar and geothermal programs from the National Science Foundation, automotive propulsion programs from the Environmental Protection Agency, as well as several other dispersed functions. Although the Energy Research and Development Administration (ERDA) was to be a transitional agency, replaced by the Cabinet-level Department of Energy in 1977, progress was made in bringing together diverse energy activities previously scattered among many federal agencies. One legacy of the Department's origins, however, is that the different areas of energy supply and end-use R&D remain balkanized--operating as isolated fiefdoms. Additionally, the Department's applied energy programs are not well integrated with either the Department's environmental or basic science programs.

The Task Force believes that one of the most important challenges facing the Department and its laboratories is to achieve greater integration of its various applied and fundamental energy R&D programs (i.e. fossil energy, nuclear fission and fusion, energy efficiency, renewable energy, and basic energy sciences). The integration that is necessary should be both internal, into a portfolio of programmatic activities organized according to a common framework of policy objectives, and external, including both cross-governmental, and Department-private sector initiatives. In the Task Force's view, there is a long list of exciting,

challenging, and vital areas of research and technology development that constitute the appropriate energy agenda for the laboratories.

It is important to note that the Department's applied energy programs are executed in a variety of ways, including at the laboratories, both with and without industry cost-shared involvement; directly between the Department and industry, through cost-shared collaborations; and directly with universities. Of the Department's FY 1994 applied energy budget of roughly $1.8 billion, only 30 percent is expended at the laboratories. The Task Force recognizes that another group of the Secretary of Energy Advisory Board is examining the applied energy programs;[1] however, in the course of our examination we did develop firm views about the energy mission both at the Department and the laboratories.

In general, the Task Force believes that the energy mission is of extreme importance and deserves greater attention by the national laboratories, working in collaboration with the private sector. Additionally, we believe that the Department needs a framework for rationalizing the management of energy supply and conservation technologies in terms of a strategic portfolio of research and development projects.

National and Global Energy Needs

During the next 20 years, world energy demand will grow by 50 percent. Most of this growth will occur in the developing world, where energy is perhaps the single most important factor for economic expansion and enhanced quality of life. Given the environmental impacts of current modes of energy use, research on means of enhancing the efficiency of energy utilization and on substitutes for fossil fuels is of critical national importance. Although oil, natural gas, and coal will remain the dominant energy source in the world for the next 20 years -- still providing as much as 80% of the global energy supply in the year 2015 -- the development of clean, sustainable, alternative forms of energy will be essential as projected fossil fuel supplies dwindle and environmental constraints mandate a dramatic switch in fuel sources during the next century. The global market for clean energy sources could be in the hundreds of billions of dollars 20 to 30 years from now, yet the R&D involved is of a sufficiently high-risk and long-term nature, and the public purpose of this research is sufficiently compelling, that it properly should be addressed through collaborative work between the public and private sectors.

The Task Force generally believes that the highest priority research areas by the Department and the laboratories are in the areas of energy efficiency,

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[1]Strategic Energy Research and Development Task Force, Chaired by Daniel Argon, President, Cambridge Energy Research Associates.

conservation, renewable energy sources (including photovoltaic, biomass, wind, geothermal, and hydrogen), and more efficient recovery of gas and oil resources. The laboratories should also continue to be involved in nuclear fission-related R&D. The Task Force was divided concerning a recommendation for the level of support needed in the area of fusion energy. At a broader level, the Task Force believes that the Department's energy programs should be managed more as a portfolio of investment areas, giving appropriate attention to the diverse and sometimes conflicting goals in various areas of energy supply and conservation R&D. These goals must be balanced with the overall energy objectives of the Department -- which must be based on the national goals for energy development and utilization.

These goals must be coordinated closely with the energy supply industry, with makers and users of energy conservation technologies, and with other stakeholders to develop a meaningful strategic plan for investments in energy supply and conservation technologies. This is the most important single aspect of the rationalization of the energy R&D work of the Department. A consensus must be developed among potentially competing technologies, users, and stakeholders that defines the R&D needs of the nation in sufficiently explicit terms that conclusions can be drawn to guide the implementation of a rational R&D strategy.

Alliances with the industrial users of the technology will be critical. R&D produces knowledge, but the implementation of that knowledge in plants and products must be done by industry. If industry is not intimately involved in the planning and development of that knowledge, they will be slow to implement it if they do so at all. The Department currently has several major collaborations in place with the Gas Research Institute, Electric Power Research Institute, fossil fuel extraction companies, and energy-intensive industrial sectors, such as the pulp and paper industry. The Task Force commends these efforts, which help guide appropriate areas of government vs. private sector R&D, and help ensure eventual commercialization of new technologies and processes.

The Task Force recognizes, however, that the energy mission of the Department is broader than the interests of the existing private sector in important ways. For example, both energy producing and energy using industrial sectors will have an inevitable bias toward existing technologies and infrastructure, and a relatively short-term outlook. The Department, on the other hand, must consider the long-term energy and economic security of the nation, which are closely linked. Accordingly, the Department must be careful to ensure that, while working closely with energy producers and users, its energy R&D program is not captured or dominated by short-term interests, since the most appropriate areas for laboratory investment using public funds will be in areas which address long-term uncertainties and needs.

Within the portfolio concept, each area of energy technology, and indeed potentially each R&D project, should be evaluated in terms of four key elements:

-Technological strength;

-Technological maturity;

-Competitive impact on public objectives (i.e., energy, efficiency, energy diversity, environmental protection, economic impacts, cost); and,

-Risk.

Section VI of this report provides additional considerations regarding the development of applied energy work at the laboratories.

## 2. The Environmental Mission of the Laboratories

The DOE laboratories have a diversified environmental mission, which includes two traditional areas of activity and one emerging area. The traditional areas are science and technology development associated with the clean-up of nuclear waste (addressed in Section IV), and R&D related to assessing the environmental impacts of energy use (e.g. global climate modeling, atmospheric chemistry). The emerging area involves systemic approaches to reducing energy and materials consumption in specific industrial applications -- such as environmentally-conscious manufacturing -- and also for entire segments of the economy.

In Technology for a Sustainable Future[1], the Administration has presented an integrated vision of long-term economic growth that creates jobs and protects the environment. Environmental technologies -- ranging from clean energy sources to energy efficient manufacturing techniques to industrial processes that create new products from waste materials to the development and use of new energy efficient materials -- are viewed as the means of helping industry shift from waste management to pollution prevention and efficient resource utilization, and a critical step toward implementing industrial ecology. This would enable companies to enhance their competitiveness by lowering energy and resource needs and reducing or eliminating waste disposal costs, and benefit the nation by reducing the environmental impact of economic activity.

The Department of Energy national laboratories should play a significant role -- in collaboration with energy- and material-intensive industries -- in the development

[1]Technology for a Sustainable Future, National Science and Technology Council, 1994

of environmental technologies and an enhanced understanding of resource utilization in the economy. The concept of "industrial ecology" has begun to take root within the private sector as a way to examine energy and materials flows for industrial systems, products, and services, with the objective of providing a systems approach to designing environmental compatibility and sustainability of those systems. The scientific and technological capabilities needed to advance our understanding of energy and material use in the economy, in an industrial ecology framework, include:

-Energy supply, distribution, and end-use science and technology;

-Advanced manufacturing and process technologies;

-Materials science and technology;

-Environmental science and technology; and,

-Modeling and simulation of complex systems.

These capabilities are broadly resident in the Department's national laboratories and are already being applied to a number of projects that hold the potential for substantial improvements in resource utilization by various industrial sectors. For example, in the general area of manufacturing and process technology, projects at the ten laboratories amount to more than $100M/year in FY 1994.

The Task Force believes that the laboratories could, and should, make a significant contribution to the integration of energy, raw materials, technology and environmental science throughout the nation's economy, and the development of the field of industrial ecology. However, at this point neither the Department or the laboratories are organized or managed to support this R&D area. Accordingly, we encourage the Department, working with the laboratories, to develop an integrated plan, based on the portfolio concept, for supporting this important area of research. We encourage the Department, as part of this effort, to establish an Industrial Ecology Advisory Board, including members from the laboratories, state, private industry, public interest groups and other government agencies.

We do not see this as a new mission area for the laboratories, but rather as an extension and integration of existing missions in energy and environmental quality. In fact, the Task Force believes that, without developing additional capabilities in environmental technology and industrial ecology, it will be difficult for the Department to carry out either its energy or its national security mission, such capabilities will augment and add value to the primary missions of the Department and laboratories, rather than being a new mission in itself. In addition, although the Task Force believes that there exists considerable potential within the

laboratories to contribute to the development of environmental technology and industrial ecology, we recognize that R&D performers in academia, industry, and other government agencies also have significant roles. The level of support to the laboratories should be determined solely by the quality of performance and the comparative advantage of these institutions in addressing complex technical challenges involving energy and resource utilization.

### 3. General Observations About Laboratory Missions

Over the past two decades, several studies of the Department of Energy's laboratories have observed that these laboratories do not have clear mission assignments which would enable them to remain tightly focused on specific national priorities and programmatic goals. This Task Force found a continuing lack of mission-derived structure both within the individual national laboratories, and across the system of ten laboratories which were the subject of this review (although the phenomenon is less pronounced at the three weapons laboratories). The multi-program laboratories currently have self-generated mission descriptions which are so broad and generalized that they are essentially indistinguishable. As such, it appears that each laboratory is attempting to keep its options open in all fields of science and technology, which is compounding the problems of effective management. Researchers at the laboratories feel a sense of drift in no small part because the laboratories do not have sufficient focus or clarity of purpose.

The Task Force believes that diffuse mission assignments for the national laboratories may have been politically acceptable and fiscally affordable during the Cold War, but do not meet the political, budgetary, management, and programmatic needs of the present and future. At the same time, the Task Force recognizes that there are important and practical limitations on how narrow one can be in delineating missions for multi-program laboratories which exhibit vast breadth both in technical expertise and programmatic activities, and whose uniqueness in large degree derives from an ability to support complex, multi-disciplinary R&D activities. Such limits also stem from the inherent difficulty of assigning goal-oriented missions to institutions which perform a considerable amount of basic research -- activities which the Task Force believes are essential for the nation, but for which the timing and nature of discoveries is fundamentally unknowable.

The Task Force did not elect to take on the task of suggesting specific areas of programmatic focus for each of the national laboratories. However, we do feel strongly that the Department and the laboratories -- working together -- must go much further than they have to-date in developing mission assignments for these laboratories which will balance both the strength of these institutions as multi-program laboratories with the need to provide greater strategic focus within a

tight federal budget environment. Such mission descriptions, which should help guide funding decisions by the Department, should:

-Capture the primary focus or strategic thrust of each laboratory, while also identifying the two or three areas of secondary importance based on specialized capabilities;

-Reflect areas of distinctive competence;

-Provide the basis for organizational coherence and motivation; and

-Be sufficiently clear and specific to enable the development of goals against which performance can be evaluated.

The Task Force believes that the development of more refined mission statements for the laboratories, disciplined by Departmental budget decisions and strategic planning, will result -- over time -- in greater differentiation and specialization among these institutions. One mechanism for institutionalizing this specialization could be, for example, the creation of a number of Centers of Excellence within the laboratory system. This will have the beneficial affect of ensuring that the critical mass of programmatic focus in various mission areas will be secured within the confines of individual institutions, rather than being dispersed at sub-threshold levels across the entire system of laboratories. It also will provide the basis for programmatic consolidation and elimination of functional activities which are being performed better elsewhere in society.

The basis for public support of the national laboratories is: 1) that they are locations for centralized, generally large-scale R&D facilities that could not be maintained by academia or the private sector, and 2) they perform R&D for which there is a strong public purpose (e.g. national defense and complex, long-term research), and which for reasons such as market failures or other deficiencies in the national R&D infrastructure, the highest quality performance is through federal funding for these institutions. The basic mission of these laboratories should be to strive for quantum advances in our knowledge base, and to work with other R&D performers to transition such knowledge into applications that meet national needs. One of the great strengths of the multi-program laboratories derives from the diversity of technical expertise that can be brought to bear from within these laboratories on specific scientific and technical challenges. In recommending that more specific missions be assigned to the laboratories, therefore, the Task Force seeks not to force specialization that would fundamentally jeopardize the multi-attribute character of these institutions. Rather, the Task Force is responding to a fundamental fiscal reality that has forced corporations and universities alike to concentrate on areas of strength, and to divest from areas of mediocrity.

While the Task Force believes there is considerable value to ensuring a concentration of capabilities at common locations, we also recognize the value of competition in spurring innovation (i.e. the highest quality proposals, as determined by peer review processes, should be the ones that are funded -- regardless of whether proposals to satisfy DOE mission assignments come from a DOE laboratory, university, or industry). However, to-date there seems to have been a pattern of spreading the wealth across the multi-laboratory system rather than concentrating resources at individual laboratories or specific Centers of Excellence.

The Task Force also recognizes that there is considerable potential in achieving greater coordination of R&D expertise across the lab complex. The national laboratories are equipped with the information technologies and the culture of communication via computer networks which could provide the basis for close programmatic integration. The Task Force believes that the goal of efficiency in utilization of the national laboratories mandates that these institutions be managed better as a system, and that complementary strengths be integrated to the extent possible through the establishment of "virtual laboratories" via computer networks and lead laboratory assignments. As the laboratories are given more discrete missions which result in enhanced R&D focus, the creation of "virtual laboratories" will be an important means for retaining complex, multi-disciplinary approaches to problem solving across the laboratory system.

## B. Recommendations

1. *The Department should organize itself to achieve greater integration among its applied energy programs, between these programs and industry, and between the applied energy and basic energy research work performed at the laboratories*. The Department's applied energy work does not appear to be managed as a portfolio, rationalized and integrated under a common strategic framework; rather, it operates like disparate fiefdoms. Greater coordination could be achieved through planning efforts that apparently do not now exist.

2. *The integration of energy and environmental considerations should be a fundamental organizing principle for much of the Department's activities*. Energy production and use, environmental protection, and economic output are increasingly interrelated, and the Department--through its laboratories--have substantial technical resources to address these national needs in an integrated fashion. At the present time, however, neither the Department nor its laboratories are organized to meet the potential that the Task Force believes exists to further the development of environmental

technologies that meet the shared needs of energy, environment, and the economy. The Department should continue and expand R&D partnership efforts between the laboratories and resource-intensive industries, utilizing the concept of industrial ecology as a method for deriving outcomes that contribute to sustainable economic development. An Industrial Ecology Advisory Board should be established to support this effort.

3. *The Department and the national laboratories should move promptly to establish clear mission statements for the laboratories which will be utilized as tools for budget decisions and long-term strategic planning*. The process of establishing missions for the laboratories should be exploited as an opportunity to clarify the precise character of the world-class strengths within each of these institutions, as well as the areas which may be appropriate for downsizing, elimination, or consolidation elsewhere within the laboratory system.

4. *Mechanisms should be established to enhance the management of the multi-program laboratories as a system*. The Department should develop a means of breaking the existing pattern of laboratory management, which treats each lab as a conglomerate of hundreds of individual programs, and all of the laboratories as separate and distinct entities. Greater efforts should be taken to coordinate and integrate the complementary strengths of these institutions through communications networks. In addition, institutional arrangements should be established to facilitate joint planning by the full group of multi-program laboratory directors and senior Departmental officials.

5. *The Department should establish lead laboratories according to mission assignments and programmatic strengths*. The current management of programs by the Department from headquarters promotes the existing balkanized structure of program execution. Lead laboratory designations would vest substantial management responsibilities closer to where the work is performed, while leaving Departmental program managers with the job of focusing on research needs, mission success, and long-range strategic policy.

6. *The Department should establish Centers of Excellence within the laboratory system*. These should reflect specific high priority national and Department research needs, and can be either wholly within one laboratory, or a virtual Center of Excellence, drawing upon the resources of several laboratories. In this way, specialization while retaining broad multidisciplinary capabilities can be encouraged.

## IV.The Environmental Cleanup Role

### A. Introduction

The Department of Energy's management of its program for dealing with the radioactive and hazardous wastes at its former nuclear weapons production sites and the national laboratories has been criticized for its expense and the slow pace of cleanup. The program is of great size and the problems that plague it, developed over decades, are acute and pervasive. Involving the national laboratories in more sweeping ways is an important part of a number of needed improvements.

### B. Background

Disposal practices for radioactive and chemically hazardous wastes from the start of the Manhattan Project of World War II, excepting high level waste, consisted of shallow burial, of injection underground using deep or shallow wells, the use of cribs or settling ponds, or direct release to rivers or streams. Some of the Atomic Energy Commission's (AEC) practices resulted in the exposure of uninformed members of the general public to substantial levels of radiation and in later years there have been well-publicized leaks of toxic and radioactive materials.

Environmental concerns in the U.S. started rising in the 1950s, initiating a new era of citizen participation, and major changes, in environmental matters. Over three dozen pieces of Federal environmental legislation were enacted by the early 1990s. The AEC and later the DOE, did not move as U.S. industry did, maintaining that they were exempted from compliance with the bulk of U.S. environmental legislation.

Although beset by increasing discontent and criticism over its practices, DOE was slow to accommodate. It continued its old patterns of behavior until, in 1984, it lost a key lawsuit brought against it. Amendments to major pieces of Federal environmental legislation now explicitly require DOE compliance. The result has been to make DOE subject to the same array of Federal environmental standards that U.S. industry had already largely adapted to. The DOE found itself 10 years behind in Environmental Protection Agency (EPA) compliance.

In 1989, the Department announced that it would have all of its sites cleaned up by 2019. This same year it created the Office of Environmental Restoration and Waste Management (since renamed the Office of Environmental Management,

or EM) to have responsibility for cleanup of the complex. The EM annual budget has risen from $1.6 billion in 1989 to $6.2 billion in 1994 and will exceed $7 billion when the Savannah River Site is transferred to it from Defense Programs. It has become the largest single item in the DOE 's $19 billion budget. It is the largest environmental restoration and waste management program in the world. Driven by heightened public and Congressional concern, DOE established, in some haste, greatly enhanced requirements governing its own operations. It initiated major growth in the number and scope of environmental, safety and health regulations, nuclear safety regulations and DOE Orders. To ensure compliance, the number of audits, reviews and appraisals was increased dramatically.

DOE now has had to cope with the series of legal commitments to cleanup performance, with milestones and penalties for non-compliance, that it signed with state and federal bodies, for each of its sites, Inadequate attention was given by DOE to the feasibility of these commitments. One example was the Tri-Party Agreement at Hanford, signed by DOE, the EPA and the state of Washington's Department of Public Health. It mandates cleanup of the site by the year 2019.

The Department has been hindered by the press of Federal legislation and regulation by other Federal bodies. A dozen or more pieces of legislation all laid on DOE burdens with which it has been poorly equipped to deal. Moreover by the 1990s, all the states had their own environmental legislation, much of it binding on the Department and not always consistent with its Federal counterpart.

The Department also is hindered by lack of credibility and mistrust, not only on the part of community stakeholders but by Federal and state legislative and regulatory bodies. Some members of these bodies continue to disbelieve the Department, as well as many of its contractors, even when they are telling the truth.

## C. Main Findings

### 1. Technical Challenges

The large quantities of radioactive and hazardous chemical waste that are at the center of concern exist in a broad variety of forms, toxicity, and storage or placement conditions. For the entire 3365 square miles of the DOE complex, now or formerly devoted to weapons-related activities there are, for example:

-3700 contaminated sites, 500 facilities now surplus, 1000 more which will be declared surplus soon, and 5000 peripheral properties with soil contaminated by uranium mine tailings. DOE might declare as many as

7000 facilities surplus in coming decades, most of which would require cleanup prior to decommissioning.

-More than 330 underground storage tanks (including those at Hanford) containing 77 million gallons of high level radioactive waste as sludges or liquids.

-Waste volumes from weapons-related activities:

- High Level Waste (HLW) 385,000 cubic meters
- Transuranic Waste (TRU) 250,000 cubic meters
- Low Level Waste (LLW) 2,500,000 cubic meters

-The LLW volume is equivalent to a cube nearly 0.1 mile on an edge which, if water, would weigh 2.8 million tons, if soil, some 8.4 million tons. The costs of disposal of low level radioactive waste (LLW) are currently in the vicinity of $5800 per cubic meter, for HLW as high as $6 million per cubic meter.

-More than one million 55 gallon drums or boxes of stored, hazardous, radioactive, or mixed (radioactive and chemically toxic) waste. An additional 3 million cubic meters of buried waste, much having breached containers, is mixed with soil underground.

-Over 100,000 gallons of plutonium and transuranic waste liquids having a high likelihood of causing environmental contamination and worker safety problems.

-More than 5700 individual "plumes," contaminating soil and groundwater, have been identified on DOE lands. For example, plumes of hazardous chemicals underlie about 150 square miles of the Hanford site.

## 2. Program Assessment

Two yardsticks are useful in judging the EM program: progress toward cleanup goals and the costs incurred, the latter related to the effectiveness of program management.

The remediation program has accomplished far less than many wish. The Government Accounting Office[1], in a recent review of management changes

[1] "DOE Needs to Expand Use of Cleanup Technologies." GAO/RCED-94 - 9205.

needed to improve applications of technology in the program, concluded that while "DOE has received about $23 billion for environmental management since 1989, .. little cleanup has resulted. Experts agree that many cleanup technologies in use are extremely costly and offer only short-term solutions." A May 1994 Congressional Budget Office (CBO) Study[2] noted that DOE "has been criticized for inefficiency and inaction in its cleanup efforts. ... (and) has been severely criticized because of the small amount of visible cleanup that has been accomplished." These conclusions are shared by many senior DOE personnel, both within and outside the program.

One of the consequences of the troubles has been the enhancement of a syndrome common to large bureaucracies: risk aversion. It has a name: "the Hanford Syndrome." It has become widespread and severe in the EM program. Its symptoms are an unwillingness to alter familiar behavior patterns, to stick with unproductive or failing procedures, to enhance tendencies for excessive resource allocation and regulation, and to oppose innovation. It is an important element in sustaining unproductive patterns of work.

The Tri-Party Agreement at Hanford, and similar ones elsewhere, have proven to constitute major constraints on remediation progress because, in many instances, they are unrealistic, not having had proper input from those experienced in actual cleanup. The milestones they incorporate, along with penalties for noncompliance, force continued activities, some of which are make-work and should be abandoned. Other activities should be delayed or modified so as to await more effective and less costly technologies. Virtually no one believes the timetables are achievable and DOE has already been forced into renegotiations, as at Hanford in January 1994. Elsewhere DOE has been paying fines, owing to the Department's incapacity to meet deadlines, as at Rocky Flats where $27 million is now due for missing cleanup deadlines.

Probably the most important reason behind the slow pace of assessment and cleanup is the low quality of science and technology that is being applied in the field. Many of the methods, such as "pump and treat" for contaminated ground water remediation, cannot provide the claimed benefits. There is a lack of realization that many_--_ and some experts believe most_--_ existing remediation approaches are doomed to technical failure. Others would require unacceptable expenditures and much extended time to reach their stated objectives.

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[2] "Cleaning Up The Department of Energy's Nuclear Weapons Complex," The Congress of the United States, Congressional Budget Office, Washington, DC. May 1994. This reference contains an extended discussion of DOE 's managerial practices, its approach to risk assessment and to the incorporation of new technologies on remediation efforts.

Over time, an increasing proportion of DOE resources has been going into DOE management in an attempt to lower environmental costs. The Congressional Budget Office report concluded that "at least 40% of the cleanup program's funds are devoted to administrative and support activities, a level that many reviewers have considered excessive. ...(they) represent a proportion that is significantly higher than the share spent by some other government agencies that may be performing similar tasks."[3]

DOE provides the most expensive environmental services of any government agency, with costs 40% above the average in the private sector. When DOE first became aware of these high costs, the Department's response was to try to lower them by an increase in management attention: it added between 1200 and 1600 Full Time Equivalents to its management and oversight personnel overseeing the remediation program.

How much the program will cost when and if completed cannot now be assessed with confidence. Estimates in the range $300 billion to $1 trillion have been made by DOE officials, but a lack of specific goals and achievable schedules as well as the absence of some critical remediation technologies make fixing the sum difficult. Some part of the facilities' contamination cannot be wholly cleaned-up; portions of the Hanford site, as well as others, will still be radioactive after many thousands of years.

## D. Disconnects

One useful way of understanding the nature of the problems plaguing the DOE program is to look at "disconnects," potentially discordant sets of activities whose discord the Department has been incapable of harmonizing. There are disconnects in three areas of major importance to the EM program: (1) science/engineering and applications, (2) regulatory, oversight and compliance and (3) goals, objectives and means, the last involving the stakeholders affected by the program. These persistent disconnects have had numerous adverse consequences on the program.

### 1. Science/Engineering - Applications

There is a marked incapacity within the Department's EM program to evaluate current and prospective technologies in a wide-ranging and competent manner based on well-assessed risks. Without the resulting information it is not possible to introduce improved technologies into the applications stream or to modify or eliminate inefficient or ineffective ones. The gap between what might be applied



[3] Ibid

and what is applied is well known within the program; it is called the "Valley of Death." In part it reflects the fact that there is inadequate communication between those attempting to remediate the contaminated sites and the research community that holds the key to identifying and readying advanced and powerful technologies.

One of the injurious consequences of the gap has been the failure to carry out a full program to characterize the waste remediation challenge across the many DOE sites: the nature of the risks presented by the diverse array of problem radioactivity and hazardous materials, the identification of applicable and available technologies to deal with them, as well as their limitations, and provide schedules, costs and expected effectiveness of reasonable and acceptable programs of remediation. The laboratories have not been tasked to perform such a characterization although they are well aware of its lack and have the technical capacity to carry it out.

The new-technology chain is seriously broken within DOE. There is little basic research being carried out relevant to the problems at hand and there is little rigorous analysis to learn from the experience in the field or from current tests. There is, for example, breakdown in communication and cooperation between organizational units within EM, from headquarters to field offices to sites. Technologies are being developed independent of field and site needs that are subsequently not field implemented because of a lack of customer interest or involvement or because they replicate work done elsewhere.

The root deficiency, which makes the science/engineering - applications disconnect a persistent problem, is the absence of a sustained, high-quality, scientific/technical review capability at a high level within DOE as well as a lack of leadership and poor management of the science/engineering - operational interface.

### 2. Regulatory - Oversight - Compliance: Management Disconnects

The host of self-inflicted, complex and frequently contradictory or redundant regulations and requirements that the laboratories and remediation efforts are subject to has become an enormous obstacle. Compliance can be quite burdensome, expensive and frequently fails to improve the affected activities. The influence of this disconnect is not confined to the EM program alone. It affects most every DOE activity, including those in both the multiprogram and the program-dedicated laboratories. Its consequences are greatest in the EM program simply because this program is DOE's largest.

In many circumstances there are harsh non-compliance provisions, and legal personal and civil penalties for failure. People are intimidated, afraid of going to jail, and this forces an excess conservatism, sometimes bordering on inaction. There is no dispute that this aggravates inherent tendencies toward risk aversion, a problem for other reasons, as noted earlier.

The managerial defects are discussed in the Appendix and are the subject of Section VII. That section should be considered an important adjunct to this present contribution for these defects have played an important role in causing and sustaining the problems in the EM program.

### 3. Goals - Objectives - Means: Stakeholders Interests

DOE has not set out to determine, in concert with affected stakeholders, the goals it should pursue, nor the standards to be met in the EM program. There is a disconnect with the customer base. Are waste-contaminated soils to be removed, remediated, left in place? What exactly is to be done to and with low-level waste? What to do about the large quantity of tritiated groundwater? What site conditions are the activities at Rocky Flats intended to achieve? No one is entirely sure. The January 1994 alterations to the Hanford Tri-Party Agreement were, in part, a consequence of some of these issues surfacing.

One result of the disconnect is too much attention to the immediate, acute problems, such as possible tank leaks, explosions, overheating, with relative neglect of longer range difficulties. The immediate matters can be serious, and must be dealt with, but the lack of a systems approach to the problems and their solutions, and thus lack of a synoptic view, means a poor priority list and provides bad choices. All of these elements lead to much ineffectual, albeit expensive activities.[1]

## E. The Future

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[1] For example, after the forced shutdown of Rocky Flats, in the fall of 1989, acidic plutonium solutions were left in a half dozen tanks in one building, with concentrations up to 125 grams of plutonium per liter. They remain there to this day, with seals and gaskets deteriorating and occasional leaks occurring. It would have required 2 weeks to one month to process and eliminate the immediate risk. There is 70 miles of piping containing Pu-nitric acid solution with 30 kg of Pu in them.

### 1. Within DOE

A well-functioning EM program with clearly defined goals is surely within reach, given a Department commitment to move forward. The model that many refer to was the hugely successful Manhattan Project of World War II, with its exquisite blend of basic and applied science underlying a large production complex, based on previously unknown physical phenomena. From it emerged the testing, production and delivery of the weapons employed just at the end of the conflict. The scientific challenge today is less profound, the managerial ones more so. A crisp, well-defined program, fully utilizing national laboratory skills, could prove a model within the Department and for the nation on how to run a major enterprise. We now have a poignant situation, for technology known to senior scientists and engineers both in the national laboratories and in the country's universities is in the wings that, appropriately applied, could dramatically alter the current prospects.

### 2. The National Laboratories

Because the EM program so badly needs high quality science and engineering development, the national laboratories together have a critical role to play, a role very much larger than at present. The laboratories have unique resources and facilities and are accustomed to the complex, interdisciplinary blend of sciences and technologies that are the mark of large, technically-driven enterprises. They are really the only organizations that can pursue the large-scale basic research and development so badly needed to replace those conventional approaches that blight much of the current EM program. Industrial site-contractors cannot carry out such tasks effectively for much commitment to basic research puts the meeting of compliance deadlines at risk, dangerous in today's climate.

Most of the national laboratories confront large ranges of environmental problems on their own sites which, while regrettable, can serve as test beds for the development of a broad spectrum of improved remediation, waste minimization and cleanup technologies for application on far larger scales.

It may be important to designate lead laboratories for major programs to be established from among the laboratories to provide the synoptic view necessary to implementation of the scientific and technical studies and demonstrations necessary for a swift and efficient program. Most all of the national laboratories have important contributions to make to the EM program; a lead laboratory's role would be one of coordination and overall systems analysis and integration for a particular major effort. This does not mean assuming management responsibilities. The responsibilities fall to DOE management and its contractors and should remain there.

An additional benefit from designation of such lead laboratories is that they could become test beds for improvements in DOE regulatory and management practices and DOE Order compliance as well as for enhanced public participation. In brief, they can act as sites for valuable pilot programs, demonstrating the benefits of positive changes.

Formal institutional connections will be required with a number of other Federal bodies whose skills or whose regulatory authority relate to the tasks of the remediation program. These include the Environmental Protection Agency, the Department of Defense, the Bureau of Mines, and others. A lead laboratory is the natural place for much of this linkage to be coordinated. Here is where special regulatory provisions must be hammered out so as not to hobble research and development work unnecessarily. Constraints on environmentally injurious activities necessary to "production" cleanup and remediation efforts are not always appropriate to research, where special relief is often required and typically difficult or impossible to get.

The recommendation to create lead laboratories could well arise naturally, in the wake of other beneficial changes, but it might be well to anticipate its arrival. The first task of one lead laboratory would be to organize the long-missing characterization of the remediation challenge mentioned earlier. This must be carried out with stakeholder participation for reasons discussed above. It would be a major program as it would require the participation of many of the Department's laboratories and EM sites . Thoughtful options would then soon appear.

There are difficulties to organizing laboratory participation. One is the need to insure neutrality or to have a sure mechanism for dealing with real or perceived drift from neutrality. A second is the absolute need for strong leadership of the whole EM program. The lead laboratory cannot provide this leadership; it must come from above.. Fortunately resolving the second difficulty would go a long way to resolving the first.

### 3. The Nation

One consequence of the activities of the United States' environmental movement is the massive environmental cleanup underway at numerous designated cleanup sites as well as at many other places in the nation. There are 60,000 EPA Superfund sites, 2400 Resource Conservation and Recovery Act (RCRA) sites, 22,00 state-funded sites, and 7200 DoD sites. The total U.S. cleanup bill is estimated to be about $1.7 Trillion dollars. The program is going slowly. "Of the $15 Billion that has already been spent on Superfund cleanups (across the nation), roughly 75% has

gone to legal fees and related costs."[1] The need for more cost effective cleanup has already become an urgent matter.

Many of the problems are very similar to those that DOE faces. In particular DOD, EPA and others are struggling with the same technology and management issues as DOE. They will badly need the technical skills that a well-organized, technically competent DOE effort, with national laboratory help, could provide. For example, volatile organic compounds in arid and non-arid soils and ground water is one of the most common environmental problems in the US. Lawrence Livermore has already made important contributions to the technology of dealing with them.

There is abundant evidence for the beneficial role the national laboratories could play in helping resolve national problems in the numerous advances that they have already made. Ocean-climate interactions are being modeled by Los Alamos in support of Global Climatic Change studies with similar global and regional atmospheric modeling at Lawrence Livermore National Laboratory. Many of the laboratories have made contributions in the areas of environmental damage and resource base assessment and diagnostics.

The Department must take positive steps to encourage this attractive opportunity. It will, among others actions, have to consider reducing its cost-recovery fees levied on all Work for Others. These fees now signal that contributions to the tasks faced by other agencies of government are not a high priority with the Department. The national laboratories could look forward to being available to the entire government system as a powerful environmental technical resource, a great national need. They should become in fact, as well as in name, national laboratories, saving our nation significant resources and improving cleanup efficiency. If the national laboratories do not fill this role, there will be no satisfactory alternative, and the need will remain substantially unmet. In any event the experience base and the technological developments arising from the continuing EM program from the laboratories', industry's and research universities' contributions should be shared with the country on a continuing basis.

A broader vision sees the U.S. environmental and resource problems as a subset of many similar ones throughout the world. Science and technology must play a key role in coping with them. A strong DOE program could contribute at all levels. We are the nation best equipped to contribute solutions. Within the US, the Department of Energy marshals the best of these skills through its national laboratories and they could be put at the world's service.

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[1] Business Week, Aug. 2, 1993.

## F. Concluding Remarks

The Atomic Energy Commission, and for many years the Department of Energy, broke the unwritten contract between these arms of government and the people they were to serve. The results, contamination on an enormous scale and a bitter distrust, imply a deep obligation to carry through the cleanup that has now been launched, with efficiency, speed, and a decent respect for the opinions and needs of those affected. This cannot be accomplished as things are now. The changes required are clear; marshal the skills high in the DOE to bring about the managerial changes that are required; raise the quality of science and engineering in the program, among others things by utilizing adequately the great power available in the national laboratories as well as the power among DOE contractors and in the universities. The changes only need to be set in place and exploited.

## G. Recommendations

1. *Sustained improvements in DOE management and leadership are needed both at senior levels in the Department and in positions below the Deputy Assistant Secretary level.* It is clear from the above material that those portions of the problems that DOE can control stem from managerial deficiencies at the top levels in the Department.

2. *A comprehensive remedy to the array of problems plaguing the EM program can only be achieved by a substantial commitment and high priority addressing the challenges of this program*. These must originate high in the Department. It seems clear that this must occur at the Under Secretary level. This does not imply disassembling the present EM structure under an Assistant Secretary. It does mean a technically adept, flexible and perceptive management of that and related efforts within DOE that acts with power.

3. *Closing the science/engineering - applications disconnect should be dealt with by the establishment of an "Environmental Advisory Board (EAB)," reporting to the Under Secretary*. This should be a permanent Board and should include mostly scientists and engineers from within and without the Department and the laboratories, as well as stakeholders, to ease public acceptance of its recommendations. A good review capability could be provided by the EAB to identify needs so as to stimulate, with Department support, the required basic research, development and demonstrations. Such advances which should then be applied, by capable management, to improve field remediation activities. The Board must have influence and visibility in order to fulfill its role as an instrument of the Under Secretary. The High Energy Physics Advisory Panel (HEPAP) and the Nuclear Science

Advisory Committee (NSAC) have such visibility, enhanced by their ability to give testimony to the Congress and their access to the Office of Science and Technology Policy. They are both widely believed to be quite successful. With members having a spread of skills, the Board should be able to provide technical oversight, flag management and regulatory disconnects as they arise and provide the synoptic view of the array of problems now lacking.

4. *The national laboratories together have a critical role to play, a role very much larger than at present, in performing high-quality science and engineering for the Environmental Management program*. Their principal contributions would be:

    -Help to characterize the waste remediation across the DOE complex as a first step in helping the Department establish priorities for environmental work.

    -Help communicate the technical challenges to the appropriate research communities.

    -Help close the "Valley of Death," by aiding the construction of a seamless technology development chain.

    The level of support necessary to implement major laboratory involvement as recommended here is small compared to the sums currently expended in the program. As an example, an increment of $400 million annually for the laboratories with a ramp-up over time to twice that sum is roughly the scale needed to pursue research and development in an improved program. In view of the large fraction of the nearly $7 billion annual EM budget that clearly is misspent now, we see no serious difficulty in redirecting funds that are already flowing. No supplemental money should be required.

5. *The Department must take positive steps to make the national laboratories available to the entire government system as a powerful environmental technical resource*. They should become in fact, as well as in name, national laboratories. The Department must take positive steps to encourage this attractive opportunity. It will, among others actions, have to drop, or greatly lower, its cost-recovery fees levied on Work for Others.

6. *DOE must address more forcefully the task of renegotiating the unrealistic or unfeasible elements of the cleanup compliance agreements that it has made with State and Federal agencies*. These are now impediments from risk management, technical feasibility, and public perception standpoints as

well as forcing large and fruitless expenditures. The Federal government's Superfund legislation also incorporates unrealistic goals; legislation in 1993, which failed to pass, addressed many of the issues which make many current remediation schemes impractical and expensive. The new Congress, as well as DOE, should revisit the issue, benefiting DOE's remediation efforts and other cleanup under Superfund.

7. *Much more comprehensive involvement by members of the affected public in decision making should be employed to reduce the bitterness, distrust and distress that continues to provide a troublesome element in DOE's conduct of its affairs.*

8. *The bulk of the EM environmental challenges, although presenting no immediate threats to public health or safety, still should be addressed with a heightened sense of urgency.* They have already been changing from acute to chronic problems, are becoming calcified, and the vast flow of funds into the program acts as an anesthetic, numbing the Department, State regulatory agencies and affected stakeholders, hindering and delaying beneficial change.

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## V.The Science-Engineering Role

### A. Main Findings

The intense economic pressures now being experienced throughout the nation's research and development system will likely persist for the foreseeable future. This means that the nation must establish what is critical to be done and make sure that it is adequately funded. It also means that institutional effectiveness, including cost effectiveness, must be a paramount goal of national research and development policies. A prerequisite for achieving this is that there be a clear understanding of the relative strengths and distinct roles of the national laboratories, the research universities, and the industrial research laboratories so that an efficient division of labor can be made among them. We will comment on this in the context of industrial technology development in Section VI. Here we focus on DOE-sponsored fundamental research in science and engineering.

The Department of Energy is one of the principal Federal sponsors of basic research in the physical sciences. The Department has the responsibility to support fundamental science and engineering in areas relevant to its broad missions in national security, energy, and environment. Exercise of this responsibility requires a long-term and broad view of the areas of science that should be developed, as well as support for the education of the future scientific and engineering workforce of the United States in these fields. Historically, the DOE and its predecessor agencies have provided important financial resources for science and engineering education. They have also supported, as a national trust, certain areas of science involving the development, design and operation of large, complex user research facilities run for the benefit of the science community at large. These scientific, technological and educational activities have contributed both essential human resources and technologies to DOE's national security, environmental protection, and energy technology missions, and have also served the national interest in other domains.

DOE's spending on basic research is heavily weighted towards its own contractor-operated laboratories -- including those considered in this study. These laboratories perform 67% of DOE-sponsored basic research, while the universities carry out 20%.[1],[2]

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[1] National Science Board, Science and Engineering Indicators - 1993, Appendix 4-11, p. 346. The data referenced here are obtained from NSF-conducted surveys and should be interpreted with caution since DOE does not budget its research according to the categories used in the surveys. In reality, it is sometimes difficult

to make the distinction between basic and applied research in those laboratories where the work is mainly applied R&D.

[2]The same preference for the laboratories is true of the DOE R&D budget as a whole. The majority (62%) of all DOE-sponsored research and development is done in the DOE laboratories, with most of the rest being done at the universities (9% ), federal laboratories
(8%) and industry (18%).

For the laboratories reviewed here, basic research accounts for varying fractions of the overall research and development effort, ranging from 56% at Brookhaven National Laboratory to only 0.7% at Sandia National Laboratory. Overall, the laboratories devote about 19% of their combined R&D budget to basic research.[1]

Most laboratory directors believe that basic research is an essential part of their portfolio of activities. We agree with their arguments that basic research is necessary to support their core missions, that it is necessary to attract the most talented people to the laboratories, and that a strong in-house community of experimental and theoretical researchers is necessary to keep major experimental facilities healthy and organic. (As a rule of thumb, one laboratory director estimates that an internal community of first-rate experimentalist capable of successfully competing for 10-20% of the available machine time is necessary for this last function.)

Basic research at the DOE laboratories is under increasing pressure. In part this is the result of the same forces that are being brought to bear throughout the nation's R&D system. But there are several additional factors that are specific to the DOE laboratories: (1) a decline in the status of basic science within DOE; (2) an increasing trend towards micro-management of research by DOE program officers; (3) the potential diversion of funds away from basic research towards the new technology transfer activities; (4) the decline in defense R&D funds, which historically have been the traditional source of support for much of the basic science at the weapons laboratories; (5) inadequate up-front budgetary allowances for operation and maintenance of large user facilities; and (6) increasingly burdensome compliance requirements, especially at large scientific facilities, which are driving up laboratory operating budgets and reducing the amount of funding available for research.

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[1] These data were obtained from the responses of nine laboratories to a survey questionnaire prepared on the Panel's behalf. (AGNAIL did not respond to the survey but does very little basic research.) The survey used the same definition of "basic research" that is used by the National Science Foundation: òThe objective of basic research is to gain more complete understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate objectives, although it may be in fields of present or potential commercial interest.ó An independent GAO survey of ten DOE laboratories found that 16% of their total R&D fell in the basic research category. The laboratoriesõ responses to the Panelõs and GAO's surveys indicate that they may see their R&D activity as more applied in nature than do the DOE respondents to the NSF survey referred to in Note 2.

The Task Force is concerned about what appears to have been a significant decline in DOE funding for fundamental research over the past three years, with the prospect of still deeper cuts to follow. The Task Force further notes that while these reductions have been occurring, overall support for basic research in the federal government as a whole has remained roughly constant or even increased somewhat.

The Task Force is also concerned that the distribution of DOE's basic research effort has failed to keep pace with recent changes in its mission. The Department is aware of the problem, and has instituted steps to address it. However, bureaucratic walls between program offices which contribute to the problem persist. As indicated in Section IV, there is a particular need for long-term, basic research in disciplines related to environmental cleanup. The activity that does exist in this area is poorly integrated into the cleanup program. By focusing too heavily on near-term demonstrations of cleanup technology, DOE is not using its laboratory capabilities effectively. The cleanup of DOE sites will not be accomplished in the near-term in any case, and in most situations there is no proximate danger to human life. Adopting a science-based approach that includes supporting development of technologies and expertise in universities as well as the laboratories could lead both to reduced cleanup costs and smaller environmental impacts at existing sites and to the development of a scientific foundation for advances in environmental technologies (see Section IV).

Compared with the universities, the main strength of the DOE laboratories in basic research has generally been in building and overseeing the operation of large-scale, complex scientific facilities (light sources, neutron sources, accelerators, reactors, etc.). However, it should also be noted that not all facilities of this type have been located at the multiprogram laboratories, and that some, including some very large ones, have instead been placed at program-dedicated laboratories such as the Fermi National Accelerator Laboratory (FINAL), Stanford Linear Accelerator Center (SLAC), and the Princeton Plasma Physics Laboratory (PPPL).

The laboratories are also capable of forming large, interdisciplinary research teams needed for certain types of "big science" problems even where large facilities are not involved. Universities are not generally as well equipped to assemble teams to conduct closely coordinated, multidisciplinary research over an extended period.

Compared with the government laboratories, the main advantages of conducting basic research at the universities lie in: (1) their primary role in educating the next generation of scientists and engineers; (2) the rejuvenating effects of the constant flow of students and post-docs through university labs; (3) the absence of national-security-related barriers to the flow of knowledge, (4) the lower price charged by the universities to sponsors for comparable research in

many cases; and (5) the quality benefits provided by the systematic application of the principle of merit-based competition. Merit review is applied to basic research at the laboratories in a variety of ways, and sometimes unevenly.

The advantages enjoyed by the universities are most pronounced in "small science." However, the DOE Office of Basic Energy Sciences also supports some individual investigator research within the laboratories on a competitive basis. To varying degrees the laboratories themselves also support such research out of their operating budgets. This type of small science research at the national laboratories is generally of a high standard, and in some cases matches the best university work in the field. On the other hand, the research culture at many of the laboratories has been influenced by their relative physical and intellectual isolation and by a sense of entitlement to research funds, and this has contributed to a loss of vitality in some research areas.[1]

The third major category of basic research institutions, corporate scientific research laboratories, are being downsized, redirected towards activities with shorter-term commercial payoff, and in some cases dismantled altogether. Historically, research at these industrial laboratories has had a different character from either university or national laboratory research. While long-term and often fundamental in nature, it has also been shaped by knowledge of markets and motivated by expectations of commercial opportunity. And as two of our colleagues have pointed out elsewhere, "the best of the industrial laboratories achieved a high degree of coherence of purpose and of organizational cohesion, which enhanced their productivity. And the larger enterprises could operate on a scale sufficient to employ experts across a broad range of relevant topics, facilitating work on many fronts.'[2]

The nation presently faces the challenge of finding an institutional substitute for the corporate central research laboratories. However, we do not think that the national laboratories provide a good institutional basis for a general solution. Partly the problem is the one discussed in more detail in Section VI. If an organization is to serve as an effective laboratory for an industry, that industry must

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[1]The panel attempted to determine in what proportions the different kinds of basic research described in the preceding paragraphs occur at the laboratories. According to the results of the survey carried out by the panel, basic research that is related to large user facilities accounts for 55% of all basic research at the laboratories; basic research that involves large interdisciplinary teams but that is unrelated to large user facilities accounts for another 34%; and general/single investigator basic research of the type most similar to university research accounts for the remaining 11%.

[2]Richard Nelson, Richard Rosenbloom, and William Spencer, "Shaping a New Era," November 1994 (DRAFT)

have a large say in allocation decisions and in evaluation. This would be awkward at best, and probably politically unliable, in a government-owned laboratory. But in addition, for a laboratory to perform the central research function effectively a considerable flow of personnel between the laboratory and the industry is required. University-affiliated facilities seem better adapted to meet portions of this need than government laboratories. In some cases, DOE laboratories may effectively be able to perform a function analogous to corporate central research. But these are most likely to be in areas where a DOE mission -- like advancing superconductivity technology -- and industry interests have a strong overlap.

## B. Recommendations

1. *The Department of Energy should move to strengthen its efforts in fundamental science and engineering, both at the laboratories and in the universities*. The DOE has vital stewardship responsibilities in a range of basic science fields, especially in some areas of the physical sciences. Moreover, a strong foundation of science and engineering should underpin all of DOE's programmatic missions. The DOE should clearly define its basic science responsibilities, pursue them in a focused way, and ensure that adequate resources are available to do this.

2. *The DOE should pay close attention to ensuring that a proper balance is maintained between the universities and the national laboratories in the performance of DOE-related basic research, both now and in the future*. The laboratories are now and should remain an important part of the nation's research infrastructure, providing cutting-edge scientific instrumentation and operating world-class research facilities. But in the future the Department will need to ensure that the basic research and associated educational programs of the universities are not jeopardized by an exaggerated flow of federal basic research funds to the laboratories.

3. *Support for operating and maintaining large facilities in the DOE's Office of Energy Research should be budgeted separately from funds for specific programs* . This will provide better accountability and budgetary control, and will impose greater discipline on decisions requiring trade-offs to be made between investing in new facilities and keeping existing ones in service.

4. *The DOE should redouble its efforts to achieve better integration of basic research, technology development programs, and their applications, particularly in the area of environmental remediation*.

5. *Basic research at the laboratories should be more fully integrated into the national and international research community*. With the exception of national security-related work, all basic research at the laboratories should be subject to external merit review. Barriers that currently prevent laboratory personnel from traveling, participating in national and international conferences, and spending sabbaticals in industry or the universities should be eliminated. Further, to help promote the vitality of basic research at the laboratories, we recommend that DOE set aside small pools of basic research funds in the different programmatic areas for which university and laboratory researchers would compete.

6. *There should be additional stimulation of laboratory-university cooperation in basic research*. This can be achieved through measures such as having the laboratories support more graduate students, especially in mission-enhancing disciplines; creating more post-doctoral positions at the laboratories; arranging for university appointments for laboratory scientists and engineers; and setting aside funds to be used specifically for collaborative research between the universities and the laboratories. Barriers that make it difficult for the laboratories to jointly fund research at universities with other funding sources should be removed. Also, laboratory efforts to promote scientific education at all levels (kindergarten through graduate school) will benefit from being more closely coordinated with parallel efforts by colleges and universities.

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## VI.The Economic Role

### A. Main Findings

The Task Force learned of significant examples of laboratory-developed technology being usefully transferred into industry and of the laboratories providing useful technical services to industry. However, the laboratories are not now, nor will they become, cornucopias of relevant technology for a broad range of industries. A significant fraction of the laboratories' industrial competitiveness activities concern technologies which are of less than primary importance to their industrial collaborators and/or which these partners could obtain from other sources. There are only a relatively few instances in which the laboratories have technology that is vital to industry and that is uniquely available at the laboratories. Many firms also find it attractive to collaborate with the laboratories because of the availability of Federal cost-sharing funds. In practice the government subsidy is often very substantial relative to the new resource commitments that the firms are making to these projects.

Taken as a whole, the industrial competitiveness activities at the national laboratories are unfocused and lack a firm policy foundation. There is uncertainty within the laboratories about how large and broad-ranging these activities ought to be, about how to fund them, and about how they should relate to the other main areas of activity that the laboratories are engaged in -- in particular, whether industrial competitiveness should be viewed as a primary or a derivative function. The uncertainty within the laboratories partly reflects an inconstancy in DOE policy and Congressional intent regarding these issues. One of the options that the Department has considered, elevating industrial competitiveness to a primary objective or mission, risks distorting existing programs and diverting resources towards activities that are unrelated to either DOE's competencies or its other missions. Such activities are unlikely to produce results that will benefit either the agency's industrial partners or the public in the long run. Recent indications are that DOE headquarters staff have recognized the need for greater focus in this area and are moving to develop criteria toward that end. We welcome these developments and encourage early discussions of the evolving situation with laboratory leadership.

Another issue requiring clarification concerns the appropriate division of labor among the national laboratories, industrial research laboratories, and the research universities regarding industrial R&D. The notion that the national laboratories should serve as a "bridge" between the research universities and industry in this arena -- a notion presented to the Task Force -- is not in general a useful way to think about this division of labor. It does not reflect what is currently happening, it

is not consistent with the fact of the research universities' superior record relative to the laboratories as agents of technology transfer, it is difficult to reconcile with any plausible view of the future evolution of these institutions, and it appears to be based on an outdated picture of industrial innovation as a linear process that originates in basic research laboratories.

A more useful picture is of the laboratories serving as nodes in a national network of research and development institutions, with knowledge flowing in both directions along the links between the laboratory, university, and firm nodes. This network is simultaneously pursuing fundamental knowledge for its own sake, innovation for the purposes of private wealth creation, and public missions (national defense, public health, environmental quality, etc.), while at the same time educating and training the next generation of scientists and engineers. Because it is a true network, each type of R&D institution is involved in some way in all of the network's activities, but there is specialization among them. While the national laboratories are one of the primary nodes for public missions like national security, their role in wealth-creating innovation is necessarily secondary (and probably even tertiary in sectors far removed from the DOE's mission areas). The question is whether, how, and to what extent they can add value to the primary role of industry in this arena.

### 1. The Case For Industrially-Relevant R&D At The Laboratories

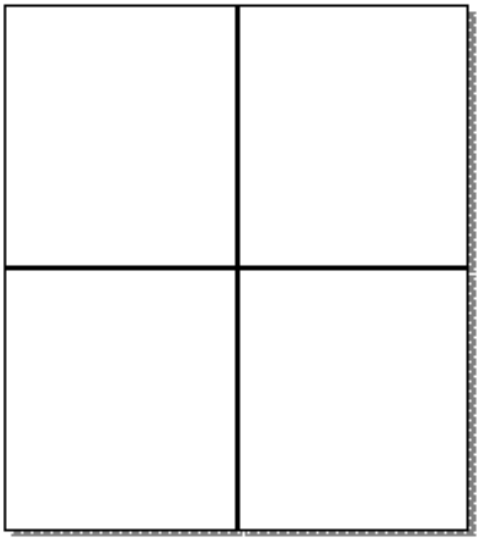
There are two principal reasons why industrially-relevant R&D is seen as an appropriate activity for the DOE laboratories. First, long-term research and development in industrial laboratories is declining, and industry is seeking substitutes for the functions that these laboratories once performed. Second, there is a perception that the U.S. government is spending significant resources on the development of new technologies but that American industry is not reaping the rewards of that investment. In the course of pursuing the DOE missions, the laboratories have developed an impressive array of core competencies, capabilities, and facilities, and to many it seems only logical that these resources be used to benefit the public in other ways.

### 2. A Critical Distinction

However, what seems to have been lacking at both the DOE and laboratory levels is a clear understanding of the distinction between the application of laboratory-developed technologies to industries where such application is an essential part of the primary mission areas of DOE (e.g., the development of energy saving technology for industry use, or the development of methods for analyzing and predicting the behavior of nuclear waste repositories, or the development of

advanced techniques for oil field simulation) and, on the other hand, the application of these technologies to industries which have not had a relationship with DOE and whose activities lie well outside the mission domains of the agency and its laboratories. Without a clear understanding of this important distinction, the risk is that DOE will allocate public funds and the technical and human resources embodied in the laboratories in unfruitful ways.

To clarify and sharpen this distinction, we have found it useful to categorize the range of possible laboratory activities in industrially-relevant R&D according to their position in the simple matrix shown in Figure 2. In practice the boundaries between the classes of activity shown in Figure 2 are imprecise, but the basic distinctions are important nonetheless. The four categories are as follows:



-Near-term R&D applied to industries outside traditional DOE mission areas (i.e., national security, energy, environmental remediation). To be effective, near-term R&D work must take place in an environment rich in interactions with users and customers. Market-based influence, direction, and control

are critical to success. In recognition of this, firms themselves have been evolving towards a more integrated process for developing new technologies, in which all participating Departments and disciplines are drawn into close and continuing interaction with the marketplace. The more distant the laboratories are from the marketplace, the more remote the likelihood that they will have something useful to contribute to such activities. Near-term development work at the laboratories is least likely to provide substantial contributions to industries outside of DOE's traditional domains of national security, energy, and certain aspects of the environment.

-Longer-term R&D applied to industries outside traditional DOE mission areas. The potential contribution of longer-term laboratory research and development to commercial applications outside the DOE mission areas should similarly not be exaggerated. While there are instances of successful "by-product" R&D, the historical evidence demonstrates that such events are statistically improbable. Even for longer-term development activity, strong interactions with the marketplace are usually essential to success. To provide industry benefits, such long-term R&D would need to be tied closely to groups of industries that have never had close association with the laboratories, their people, or their culture, an unlikely prospect for creating useful results. Moreover, to be useful in a different industrial context, substantial technological modifications are almost always necessary, so if the laboratories are engaged in such activity resources will inevitably be diverted from their primary missions.

-Longer-term R&D applied within traditional DOE mission domains. For firms and industries that are contributing to DOE's traditional mission objectives, the national laboratories have a useful role in carrying out long-term research and development with potential commercial applications. Indeed, it is even possible to imagine the laboratories playing a role with respect to these industries comparable to that which used to be played by central corporate research laboratories. Here the alignment between DOE and industry objectives is much closer by definition, and both DOE and its laboratories have more knowledge of their industrial partners' market environment. Longer-term research and development of this kind undertaken by the laboratories does not require day-to-day direction by industry, but close interactions are still important.

-Near-term development applied to traditional DOE mission domains. Firms and industries that are participating with DOE in pursuit of its traditional missions of national security/energy/environmental pollution control and remediation may become aware of technical developments at the laboratories that will help them in solving a short-term product or process

development problem. In such cases industry should be an active partner in directing the course of development, and should be encouraged to transfer interim laboratory outcomes into its own internal industrial R&D programs through the appropriate licensing mechanisms.

### 3. Expansion Outside DOE Mission Areas

We are concerned about the implications of expanding the laboratories' industrial R&D activities outside the existing DOE mission areas. If the DOE is to get into programs whose primary mission is to meet a need of private industry (as contrasted with programs where private industry needs are complementary to government needs, but not dominant), private industry will need to have a large say in allocation decisions and in evaluation, since only industry has the intimate knowledge of the marketplace that is critical to the success of such efforts. The difficulty comes in reconciling this need for industry direction with the parallel need for public influence over the disposition of public resources at government laboratories.

We are also concerned that the expansion of the laboratories' roles in serving the technology needs of private enterprise will create additional managerial problems within DOE. For any organization to be effective, the activities it manages need to be associated with a coherent set of objectives. Otherwise, it is virtually impossible to allocate resources rationally, or to evaluate the various activities and programs in terms of how they contribute to the performance of the organization as a whole. This is amply borne out by experience in private enterprise which indicates that most conglomerates do badly, especially in managing technological innovation. Under statute, the DOE is faced with the considerable challenge of managing an already diverse set of missions. Adding to this complex task the requirement to consider the technology needs of the private sector in areas not related to the Department's traditional domain of activity is likely to distract DOE from its public missions and lessen its impact while undermining the effective pursuit of those industrial objectives. We are concerned that "porkbarrel" criteria for program funding might increasingly replace more rational resource allocation, and that the laboratories might be more likely to propose industrial programs merely based on "make work" criteria.

We are further concerned about the possibility that DOE and its laboratories, in engaging in industrial R&D, may find themselves competing with private firms in providing technical services or new technological developments. In such a situation, the laboratories' access to public funds would give them an inappropriate advantage. Such situations are more likely to arise the less DOE and laboratory management know about the commercial application in question. We are already aware of some instances in which such competition appears to have

occurred, and we are concerned that the problem may become more serious in the future.

All of these problems can be ameliorated if the industrially-related R&D done by the laboratories is focused on industries and applications which are themselves instrumental to achieving the DOE's public missions. That is not to suggest that laboratory directors should be denied the flexibility to initiate new technical projects at the periphery of current activities. Making room for individual and small group initiatives of this kind is an important way to keep the laboratories lively and exciting places to work. If such a project becomes large enough, though, a judgment must be made as to its fit with the rest of the laboratory's activities. This will depend not only on technical compatibility but also on the project's relevance to the laboratory's (and hence the DOE's) missions.

The current industrial partnership activities of the laboratories have brought them into contact with a number of industries that do not lie within the Department of Energy's traditional domain. In addition to the drawbacks specified above, these new involvements also suffer from a number of other problems:

-They are unfocused. Without a connection to the Department's larger public missions, these initiatives are invariably add-on activities, managed on a case-by-case basis, through a well-intentioned but necessarily ad hoc relation to industry. The laboratories should not aspire to become research boutiques for industries.

-Their short-term benefits are often oversold. Even when useful results flow from these partnerships, the benefits to the participating firms generally will not be evident for some time, and are inherently difficult to measure.

-They distract the DOE and its laboratories from their public missions, diverting both intellectual and material resources.

### 4. Technology Partnership Mechanisms

Cooperative Research and Development Agreements (CRADAs) currently occupy pride of place among the array of mechanisms employed by DOE to encourage laboratory-industry cooperation in technology development and transfer. Introduced to the laboratories in 1989, the CRADA mechanism reflects the intent of Congress, developed and refined in legislation over the preceding decade, to ensure a greater degree of laboratory involvement in industrially relevant activities. Industry criticism of the CRADA mechanism has focused on the slow and uncertain nature of the negotiation process. The DOE and the laboratories have responded to these concerns. Nevertheless, there remain wide variations across

the laboratory system in the speed with which CRADA negotiations are being concluded. Ironically, recent contractual reforms intended to encourage more businesslike relations between DOE and its management and operations (M&O) contractors at the laboratories risk complicating laboratory/industry negotiations because the contractors are more strongly motivated than before to secure rights and to take direct profits from laboratory-generated intellectual property. The Task Force believes that the contract-driven M&O motivation to profit from laboratory intellectual property will act as a significant barrier to industry acquisition and subsequent commercialization of laboratory technology in the future.

Other criticisms focus on the lack of independent review of the operation and outcomes of CRADAs[1], and also the process used to select industrial partners for these agreements. Regarding the latter, when a CRADA proposal is submitted there is typically no solicitation of competing proposals, nor an announcement that public resources are available for such work and will be awarded exclusively to the applicant company if others do not step forward. Nor is the peer review process as rigorous as other DOE programs; independent expert evaluations of the validity of the proposed work and its relevance to the DOE mission are not routinely solicited. These practices can be traced to earlier legislative and executive branch attempts to reorient the laboratories towards industrially relevant activities as rapidly as possible. However, their practical effect today is to leave the laboratories vulnerable to charges that the selection process is flawed and that the competitive playing field is being unfairly tilted towards the laboratories' chosen partners. In fact, DOE routinely and successfully implements several different models of independent peer review, at least two of which are relevant to the present situation -- the allocation of DOE beam line resources, and the allocation of funds under the Small Business Innovation Research (SBIR) program. The DOE should consider applying these practices to CRADAs as well.

## 5. Metrics

One of the most common metrics used by DOE and others to assess the technology transfer performance of the laboratories is the rate at which new CRADAs are being signed. An obvious limitation of this metric is that it measures inputs rather than outcomes, and the latter are likely to vary greatly from one

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[1]Post-CRADA follow-up work at the laboratories would be classified as "work for others", for which the industrial partner is required to pay the full cost. Many industrial partners would at that point be inclined to pull the work back into their own facilities. Since the laboratories would then lose their DOE-budgeted CRADA financial resources, in the absence of independent review there might be a tendency for valid and successful CRADAs to continue beyond the completion of technology transfer and into product development or some other industrial activity.

CRADA to another. It also fails to distinguish among different classes of CRADAs. Some pertain to work that the laboratories would have undertaken anyway, even if no CRADA had been signed. Others entail a significant departure from a previous program of work. In some cases technology transfer activities have reportedly drawn the laboratories away from their primary missions. In others, resources appear to have been diverted away from fundamental research to support them. In such cases, a cost-benefit metric may be the only meaningful measure of performance. We also note that none of the laboratories appears to be measuring the effectiveness with which technology is being transferred in from industry or the universities to support their missions. In general, we recommend that greater emphasis be placed on outcomes in the measurement of technology transfer performance. The question of performance metrics for the laboratories in discussed further in Section VII of this report.

## B. Recommendations

1. *The government-funded technology transfer/industrial competitiveness activities of the national laboratories should be focused on industries and areas of technology that contribute directly to the DOE's primary missions in national security, energy and environment*. Industrial competitiveness, broadly defined, has no place as a stand-alone mission of the laboratories, but rather should be regarded, and treated, as a derivative of their primary missions. The idea that the laboratories are, or could become, cornucopias of relevant technology for a broad range of industries is a myth.

2. *Laboratory directors should have the flexibility to initiate or to approve new technical projects at the periphery of current laboratory activities*. But if these initiatives are unrelated or only tangentially related to the public missions of the DOE, either different sponsors should be found or the work should be spun off into the private sector once the level of activity exceeds what can reasonably be funded out of the laboratory director's limited discretionary account.

3. *Competitive selection and more rigorous technical and merit review by external experts should be applied broadly within the Department's CRADA activities.* There are several alternative models available to DOE for this purpose, including programs currently administered by the DOE itself. One strategy would be for DOE to link some portion of its SBIR programs to CRADA activities. The two programs have similar legislated commercialization objectives, which should make them compatible. In addition, making this linkage would help to achieve a higher commercialization rate by maximizing the available resources (both cash and in-kind R&D). Improvements in the CRADA selection and monitoring

process need not, and should not, incur any penalty in the timeliness of the process. The DOE should continue to focus on reducing the time required to complete CRADA negotiations and on bringing the laboratory system as a whole up to the standard of best practice established by the leading laboratories.

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## VII.The Governance and Organization Issue

### A. Introduction

In accepting its privileged assignment of suggesting alternate futures for ten Department of Energy laboratories, this Task Force could have limited itself to the conventional objective of most Federal advisory studies and only presented findings and proposals that might be adopted within the accepted governing processes of the times. But one critical finding is so much more fundamental than we anticipated that we could not in good conscience ignore it. The principle behind that finding is: Government ownership and operation of these laboratories does not work well.

The laboratories are purported to be contractor operated. The system is titled Government-Owned, Contractor-Operated or GOCO. The GOCO system was a promising concept. The Contractors, as contractors, do yeoman work. The system has been employed for decades. But in that time it has followed the natural course of government's proclivity to govern more. The owner wants to take charge more. Most able government personnel aspire to add value. Translation: add more governance. This makes work for more government personnel, increasing the size of the operation, increasing still further need for management, *ad infinitum.* Congressional policy has significantly driven this consequence.

Numerous instances of poor DOE regulatory and management practices have come to the attention of all members of the Task Force during its investigation of the national laboratories. The system has been tried long enough; the evidence is in. Today, the system has evolved to a virtual GOGO - Government-Owned, Government-Operated, but certainly strongly government-dominated system. And the momentum in that direction has been unabating. This ship of state (the Congress/Department/Contractor/Laboratory system) is ponderous. Evidence in these regards is almost limitless. Appendix A illustrates the excessive oversight and micromanaging with an abbreviated litany of some forty anecdotes. However, general areas of excess are:

-Growing emphasis on DOE administration and support organizations and their oversight and compliance roles;

-Expanded DOE field office management oversight roles, which are commonly duplicative of other management channels;

-Increased audit oversight and too many review groups, both internal and external. The increasing costs of dealing with review groups, both in

resources and in their consumption both of senior and junior staff time, leads to paralysis and interferes with operations; and

-One array of difficulties with which DOE has not yet been able to deal properly is ironically self-inflicted. Far too much influence has been ceded to non-regulatory advisory boards, such as the Defense Nuclear Facilities Safety Board. Such organizations generate recommendations with no apparent cost / benefit analysis, resulting in significant unnecessary expenditures and productivity losses.

As we were in the final stage of editing our report and preparing for submission, the Department initiated a Strategic Alignment effort to address some of these issues. The initiative is described in the announcement and explanation documents of the Department which were released on December 20, 1994. The Task Force applauds the Department's acknowledgment of the problem and many of its intended actions. The Task Force presumes no credit for this happening. Rather, we note that the establishment of this Task Force was itself an initiative of the Department a year earlier. The natural consequence was to put the governance issue into public play, and the Department has been responsive to the inevitable greater emphasis of this governance issue to its credit.

There is heartening evidence from inside the Washington Beltway regarding the suffocating consequences of micromanaging. It confirms our finding that something really substantial has to be done soon or the vitality of the laboratories will founder. But our evaluation of the seriousness of the problem and the limited promise of a continuing federal governance system even though partially muted, per the new Department proposals, is that efforts such as announced will be seriously insufficient.

It is the Task Force's position that top-down, command and control bureaucracies are counterproductive for these laboratories. Pundits may dismiss this reality. But if the laboratories are to optimally enhance America's energy interests, these are the realities of group dynamics essential for the laboratories to contribute their best.

Thus, our first operations recommendation is that we must begin to evolve, over a period of one or two years, the development and implementation of a new *modus operandi* of Federal support, based on a private sector style corporatized laboratory organization system. This proposal embraces the counterintuitive, yet newly-further-confirmed institutional principles that allow the subsets of an organization to operate more to the principles of trust and self initiative. From these principles accrue greater flexibility, quality, and productivity; as well as the revitalization of an operating institution and the heightened accomplishment of its mission.

There have been many studies of the Department of Energy laboratories. As one reads these reports, one recognizes that the items which were recommended in previous reports are for the most part recommended in most subsequent reports. As each past study has taken place, people of good intention do make sincere efforts to fine tune the system. However, the Department and the Congress should recognize that there has been little fundamental improvement as a function of past studies. In fact, the cost-benefit relationship of the Department/Laboratory operation has continued to degrade. If there is to be a significant benefit from this study, it will have to come as a function of a major organization and governance change.

We suggest that the country must try one or more concepts that are radically new in order to revitalize the laboratories and to achieve significant improvements. If some parts of a bold solution were to prove to be not as beneficial as this Task Force is confident that they would be, that unto itself should not be a matter of concern. The laboratories and the country would still be better off than they otherwise will be from the continual repetition of federal governing policies. The system is now so concerned with details that it cannot work the big picture.

Previous reviews of the laboratories have taken a top down approach. This one focused otherwise. Early on we invited the involvement of the people active in the system from the bottom up. It is evident to us that the competence is there in the laboratories to make these changes. Properly oriented and supported with quality management training, this inherent competence can make enormous changes in the productivity and effectiveness of the laboratories.

## B. The Need to De-Federalize

The principal organizational recommendation of this Task Force is that the laboratories be as close to corporatized as is imaginable. We are convinced that simply fine tuning a policy or a mission, a project, or certain administrative functions will produce minimal benefits at best.

The government should be the customer of the laboratories. The Department itself should be an instrument of that customer function. The Department must become a world-class customer. World-class commercial customers do not tell their suppliers how to do things. They simply buy a result for a given price. World-class commercial suppliers are not audited by their customers. The commercial practice sets the quality of operations standards to which the government should commit.

The Task Force is aware that there are numerous laws on the books that specify that things should be done the way they are currently being done. The Task Force recommends that a clean sheet of paper be applied to the design of a new laboratory governance system by the Congress and the Department. The Task Force notes that over the years creative variations of government structures and funding have been flexibly initiated, including the Defense Advanced Research Projects Agency (DARPA, now ARPA) the Federal National Mortgage Corporation, Mitre Corporation, and many others. This precedent justifies the application of imaginative and practical forms and financing of organizations such as we propose, including the circumscribing of prescriptives, audits, and other overhead.

One attractive model that we outline here is the creation of a new not-for-profit R&D corporation or corporations, formed with many of the basic principles and criteria of a conventional commercial corporation. Although the DOE weapons-oriented laboratories could be omitted from the proposal outlined here, many if not all of the other DOE national laboratories at least are candidates to be included in this corporation. The not-for-profit corporation(s) will be governed by a Board of Trustees, consisting primarily of distinguished scientists and engineers and experienced senior executives from U.S. industry, appointed to staggered terms by the President of the United States. This Board will select the chief executive officer and other principal officers of the corporation. Each lab would similarly have a trustee advisory board elected by the parent board.

The Department of Energy will be the government sponsor of this new R&D entity. Initial funding of the corporation will be in the form of Congressional line items in the DOE budget in each of the four mission areas of national defense (if the weapons laboratories are included in the corporation ), energy, basic research and environment; and another line item for other programs, a miscellaneous category including health, facility improvement, global ecology, economic betterment, etc. Each of those missions will contain funding that can be used across the full R&D spectrum from basic research to development and technology demonstration. The budget should be for some multiple of years with our Task Force recommending that a decline be built into these funds over a five year period. Renewal of federal funding will be subject to Congressional approval.

Allocation of these funds among its several individual laboratories will be made by the corporation. The management of the corporation will deal with the traditional agencies for which the work is usually done in refining the allocations. Micromanaging or earmarking of these allocations should not be made by the Congress or the Department.

The corporation will be permitted to serve the particular needs of the Department of Defense, the Department of Energy, as well as any others in government, the universities and the private sector, just as any corporation would serve its

customers. The corporation will be subject to normal commercial criteria of operation, including conventional outside auditors, as are required of other corporations. The corporation and its several laboratories will be subject to the normal influence and control of those agencies of the state and federal government that normally have authority over a United States corporation. If it wishes, the corporation may hire one or more contractors, similar to those now engaged by the DOE, to assist it with aspects of the management of its affairs.

The laboratories will be challenged to embrace the new higher standards of self initiated, self determined, quality service to customers that are being perfected in the private sector. As a result, the Department will receive more bang for the buck . There is a spectrum of possibilities from which a new system of governance and operation can design the needed better way. Although we have outlined one specific embodiment of a corporate structure, many variations are possible. As mentioned above, the weapons- laboratories may or may not be included in such a corporatizing, although some Task Force members feel including them would be both useful and successful. Various options also exist for ownership of the plants and facilities. For example, they may be leased to the corporation on a long-term or rolling basis, or they may be transferred outright. Combinations of operating plans can be staged in transition to a far-less-federal plan as a further possibility.

In this model, the DOE is the customer of the corporation. Funding for the corporation would be allocated to the DOE by Congress in a small number of broad blocks as described earlier. Allocation to specific projects would be the responsibility of the DOE, with no earmarking from Congress beyond quantifying the amount of money given to each broad block. Congress would indicate its level of satisfaction with the job the DOE was performing by increasing or decreasing the funding to each broad block. The DOE, in turn, would indicate its satisfaction with the job the corporation and its parts are performing by increasing or decreasing the level of funding for each project.

The contemporary official view is that the laboratories must conform to the so-called federal norm. The Task Force believes it is time to run a major experiment with a modest part of the federal budget and have the laboratories test out a progressive concept. The current annual budget of some $6 billion for these laboratories is modest compared to the entire government budget, or even the budget of many large corporations. At minimal risk, the country could experiment with a new way of doing things. It is just such quality of change that is renewing the rest of America to heightened achievements and increased competitiveness with resultant ability to achieve improved results with a smaller budget.

A compelling question is: what are the cost savings consequences of the change in governance and reorganization? Each time we tested the question on the

players-those who work in the laboratories-the least called out was 10% savings ; to which most all other respondents would strenuously interject 40%, 25%, 50%, 20%. In private industry it is virtually axiomatic that a dedicated, empowered, quality program will generate better than 20% cost improvements with greater values in significantly improved quality of output of services, engineering and product.

As described in its Strategic Plan, the Department of Energy sincerely desires to be people oriented, to value creativity and innovation, to commit to excellence, to work in teams, to embrace leadership empowerment, and to pursue accountability. Regrettably, the fundamental system and structure under which it is obliged to operate cannot achieve the first five objectives to near the degree the Department leadership intends. The Department further recognizes that certain critical success factors are communications, trust, and human resources. Again, its hands are tied as it is obliged or elects to overadminister. The activities that it is obliged to direct and order are a countervention of the value of trust. The laboratory human resources are demotivated by such an environment.

The above are our recommendations of the type of substantial reorganization which could be expected to result in an improvement of between 20 and 50 percent in the effectiveness of the laboratories themselves, on top of significant staff and overhead economies in the Department. For example, under the proposed structure the present DOE Field Offices might have no role to play vis-a-vis the laboratories.

In implementing the proposed corporatization, a separate detailed identification of those services which only the government can provide as a supplier should be identified. One example may be the transportation of nuclear or other dangerous materials. These services could be purchased by the laboratories from the government.

Certain of the liability responsibilities that have been placed on the government's shoulders must be continued (at least relating to past government assignments, such as nuclear materials) absent bad faith and willful misconduct on the part of the laboratory corporations.

## C. Other Subjects

### 1. Financial Resource Planning

The laboratories must have a reasonable predictability as to their financial resources. In this way, the people who work at the lab will be more secure in their professional futures, and will be further motivated to become the supremely

productive entity to which they aspire. Some form of multiple year fund guarantees are essential. We must find a way under the clean sheet of paper doctrine of making this possible. We must further be willing to find ways of engaging cooperatively with foreign sources of funds for research and development, as such cooperative work will often multiply the effectiveness of the domestic work to our benefit.

### 2. The Laboratories As a System

One of the values of this Task Force process has caused the laboratories to come together as a system to a greater degree than they had been inclined or directed to do in the past. The laboratories could move to a virtual system, such as is described elsewhere in the report. This would be more readily accomplishable under Corporate structuring.

### 3. Technology Roadmaps[1]

The Task Force suggests that there be a more liberal application of the technique of defining technology roadmaps for those classes of technology which would yield to a roadmap. We urge that this management process be employed where practical. All appropriate constituencies from government, academia, industry and the laboratories who have a competence at contributing to a given roadmap, should be called upon to define such roadmaps in a manner similar to that which has been accomplished by the semiconductor industry.

### 4. The Globality Issue (vis-a-vis non-Defense technology)

These laboratory Corporations will be serving other private corporations. They must not be unduly inhibited by policies that restrict the use of the technology to American sites or to American personnel. This is a global energy economy and general economy. All users of knowledge must be able to use the knowledge, wherever that knowledge can best serve their customers. If that requires doing some further engineering or production overseas, such investments will do nothing but enhance the economic strength of America through exports and the lowering of trade barriers, with the eventual desired job creation at home. Some further liberalizing of the design and manufacture only in America must be effected.

### 5. Metrics

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[1]A technological development plan which outlines, over time, the evolution of technological capabilities and provides milestones by which progress can be measured.

At the onset of the Task Force study, a request was made to identify metrics of the laboratories' work. In no order of importance these can include: adherence to budgets, adherence to project schedules, patents filed, inventions disclosed, estimates of cost savings from a given potential application or actual application of technology, lists of technical problems solved, research dead ends now avoidable, the quantity and quality of research papers published, lab/university and lab/industry interactions as well as other collaborative work anecdotes, including CRADA results. The presently overused metric of jobs expected to be produced from a CRADA should be discouraged as speculative at best.

The degree to which a laboratory engages in the process of renewal would be a significant measurement. Science change, laboratories change, and laboratories' missions change. Laboratories such as Lawrence Livermore, for example, have changed over the last forty years having naturally gone from an 90 percent national security orientation to a 60 percent other class of activities orientation. Major projects like the Bevatron at Lawrence Berkeley Laboratory, which played an early important role, have been closed.

It is worth having metrics on how well the government is performing to make possible the better work of the laboratory and to expedite the application of certain of the output of the laboratories. For example, to what degree is the government becoming a better customer of the development, to what degree is it moderating regulations, to what degree is it making aid available tied to the development to encourage the commercial exploitation, to what degree is it making available low cost capital, what are the practical honorable ways of reducing the risks that would be borne by investors, how is the network of extensive testing facilities used to enhance and advance the application of products, how willing is the government to identify with the beginning success of a technology roadmap to support more vigorously extensions of achievements on that roadmap.

When all is said and done, the nature of the laboratories as a multidisciplinary system providing solutions to some of the truly challenging puzzle of nature, will require a qualitative evaluation more than anything else and a long time horizon to best measure the results.

### 6. Quality

The Department of Energy and most of the laboratories have embraced the language of quality management. They have studied the issue, they articulate the principles and they are educated on the fundamentals. The pursuit of these

quality initiatives and the embracing of the practical methods and procedures of quality should produce values for the Department and the laboratories.

However, the likely end result will be limited because the principal authorities do not adequately appreciate a major way one improves quality: the elimination of functions. One must simplify procedures and get down to their essences, and the people in government are not prone to this. They administer quality in, control quality in, and audit quality in. Exactly the opposite is obliged. One cannot have a quality effect through the manner in which government imposes itself on the operations of the laboratory. We call for a true quality program. It must start at the top. It must start with the Congress and the Administration. When it starts there with proper respect for the essential principles, the ultimate result will require the government to get out of the way so that the laboratories can practice the quality principles that are practiced in the private sector.

Consider this excerpt from an article, Why to go for Stretch Targets, in Fortune Magazine: Finally_--_ and here's where stretch targets differ from old-fashioned top-down management by fiat that U.S. companies have spent years unlearning_--_ the CEO has to get out of the way. The job belongs to managers in the field, workers on the plant floor, and engineers in the labs. [1]

### 7. Facilities

There are superb facilities at the government laboratories. There are also facilities that have been allowed to languish. The insufficient attentiveness of the Department in keeping up the quality of existing facilities or the disposition of obsolete facilities is evident.
There should be a gradual reinvestment by the federal government in repairing research laboratories, and upgrading research instrumentation. Once that has been achieved after a period of years, the responsibility should be turned over to the laboratories. The laboratories should be expected to maintain and renew facilities in the same manner that the private sector is obliged to perform the updating, the tearing down and the construction of new facilities from their then aggregate budget assignments.

Elements of such a facility renewal plan should include:

-Facility consolidation, including decontamination, decommissioning and disposal of all non-essential structures and equipment.

-Upgrading all essential facilities to meet modern safety facilities.



[1] Fortune Magazine, November 14, 1994, pg. 146

-Initiate an enhanced maintenance program for all nuclear facilities bringing ongoing maintenance to appropriate industrial standards.

-Complete and maintain all safety related documentation.

-The laboratories should see to the training of the work force to successfully implement and maintain safety and environment systems regarding such facility.

If we do not correct this facility situation, the cost of managing and maintaining facilities today's way will soon be so costly that it may substantially consume the laboratories' budget. If the full management responsibilities of the facilities are placed in the hands of the management of operations (that is, the laboratory directors responsible to their public trustees), we anticipate that the cost of facility maintenance will be significantly improved.

**D. Recommendation**

*1. Over a period of one to two years, the Department and Congress should develop and implement a new modus operandi of Federal support for the national laboratories, based on a private sector style - corporatized - laboratory system.*

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*2.*

## VIII.Summary of Recommendations

For detailed versions of the following recommendations please refer to the body of the text.

### A. National Security

1. The primary mission of the weapons laboratories must be a safe, secure and reliable nuclear stockpile in the absence of explosive testing. Science-based stockpile stewardship is the approach chosen be the Department to achieve this mission. It requires the following rank-order priorities:

- Attracting and retaining skilled scientists, engineers, and managers over the years ahead with the expertise required for the complex and changing stewardship role;

- Enhancing surveillance of weapons in the stock pile, during dismantlement, and of the nuclear materials that accumulate as a result of the dismantlement;

- Continuing hydrodynamic testing to cope with problems;

- Assessing problems, reanalyzing previous data through numerical simulations, and developing appropriate data bases; and

- Sustaining the scientific process of inquiry through experimentation.

2. Non-proliferation, counter-proliferation, verification, and intelligence support have become a major mission along with stewardship of the nuclear stockpile. The Task Force notes that organizational compartmentalization within the Department complicates and makes difficult the appropriate inter-relationship and funding balance between support and non-proliferation, and recommends that the Department's organization reflect their importance and interdependence.

3. The Task Force believes Lawrence Livermore National Laboratory should retain enough nuclear weapons design competence and technology base to continue its activities in non-proliferation, counter-proliferation, verification, an intelligence support, to provide independent review for several years while alternative approaches to peer review are developed, and to participate in weapons relevant experiments on the National Ignition Facility (NIF). Lawrence Livermore National Laboratory would transfer as cost-efficiency allows over the next five years its activities in nuclear materials development and production to the other

design laboratory. Lawrence Livermore National Laboratory would transfer direct stockpile support to the other weapons laboratories as the requirements of science-based stockpile stewardship, support of the DoD nuclear posture, and the status of the test bans allow.

4. The Task Force recommends continued funding support for the Dual-Axis Radiographic Hydrodynamic Testing (DARHT) facility; continued near-term support for the Los Alamos Neutron Scattering Experiment/Los Alamos Meson Physics Facility (LANSCE/LAMPF); continued pursuit of advanced computing, including computing through workstation networks; and proceeding with the National Ignition Facility (NIF) as a research facility, balanced with respect to other major investments.

5. The Task Force recommends that future production needs should be based on residual capabilities of Pantex, Los Alamos National Laboratory, and Sandia National Laboratories, and believes that no further investments in production capability are needed at this time.

### B. Energy, Environment, and Related Sciences and Engineering Role

1. The Department should organize itself to achieve greater integration among its applied energy programs, between these programs and industry, and between the applied energy and basic energy research work performed at the laboratories.

2. The integration of energy and environmental considerations should be a fundamental organizing principle for much of the Department's activities.

3. The Department and the national laboratories should move promptly to establish clear mission statements for the laboratories which will be utilized as tools for budget decisions and long-term strategic planning.

4. Mechanisms should be established to enhance the management of the multi-program laboratories as a system.

5. The Department should establish lead laboratories according to mission assignments and programmatic strengths.

6. The Department should establish Centers of Excellence within the laboratory system.

### C. Cleanup of Radioactive and Chemical Wastes

1. Sustained improvements in DOE management and leadership are needed both at senior levels in the Department and in positions below the Deputy Assistant Secretary level.

2. A comprehensive remedy to the array of problems plaguing the EM program can only be achieved by a substantial commitment and high priority addressing the challenges of this program.

3. Closing the science/engineering - applications disconnect should be dealt with by the establishment of an "Environmental Advisory Board (EAB)," reporting to the Under Secretary.

4. The national laboratories together have a critical role to play, a role very much larger than at present, in performing high-quality science and engineering for the Environmental Management program.

5. The Department must take positive steps to make the national laboratories available to the entire government system as a powerful environmental technical resource.

6. DOE must address more forcefully the task of renegotiating the unrealistic or unfeasible elements of the cleanup compliance agreements that it has made with State and Federal agencies.

7. Much more comprehensive involvement by members of the affected public in decision making should be employed to reduce the bitterness, distrust and distress that continues to provide a troublesome element in DOE's conduct of its affairs.

8. The bulk of the EM environmental challenges, although presenting no immediate threats to public health or safety, still should be addressed with a heightened sense of urgency.

### D. Science-Engineering

1. The Department of Energy should move to strengthen its efforts in fundamental science and engineering, both at the laboratories and in the universities.

2. The DOE should pay close attention to ensuring that a proper balance is maintained between the universities and the national laboratories in the performance of DOE-related basic research, both now and in the future.

3. Support for operating and maintaining large facilities in the DOE's Office of Energy Research should be budgeted separately from funds for specific programs.

4. The DOE should redouble its efforts to achieve better integration of basic research, technology development programs, and their applications, particularly in the area of environmental remediation.

5. Basic research at the laboratories should be more fully integrated into the national and international research community.

6. There should be additional stimulation of laboratory-university cooperation in basic research.

### E. Economic

1. The government-funded technology transfer/industrial competitiveness activities of the national laboratories should be focused on industries and areas of technology that contribute directly to the DOE's primary missions in national security, energy and environment.

2. Laboratory directors should have the flexibility to initiate or to approve new technical projects at the periphery of current laboratory activities.

3. Competitive selection and more rigorous technical and merit review by external experts should be applied broadly within the Department's CRADA activities.

### F. Governance

1. Over a period of one to two years, the Department and Congress should develop and implement a new modus operandi of Federal support for the national laboratories, based on a private sector style - corporatized - laboratory system.

# Appendices

## Appendix A: Excessive Oversight And Micromanaging

The present structuring and operation of the laboratories is governed by the class of contracting: Government-Owned, Contractor-Operated (GOCO).

Were it possible to have a true government-owned, contractor-perated system it is conceivable that there could be a continuing activity under such a rubric. But wherever we turn we see evidence of nothing but a government owned and more government operated system.

As a function of the detail with which the Congress prescribes what should be done in the laboratories and the Congress's obsession with the issue of accountability, the Department is driven both to honor the prescriptions from Congress and to overprescribe in order not to be at risk of failing to be super attentive to the Congress's intentions.

The net effect is that thousands of people are engaged on the government payroll to oversee and prescribe tens of thousands of how-to functions. The laboratories must staff up or reallocate the resources of its people to be responsive to such myriads of directives; more and more of the science intended resources are having to be redirected to the phenomenon of accountability versus producing science and technology benefits.

This report could contain thousands of supportive pages from the thousands of involved people who unanimously complain of this phenomenon. We will merely illustrate with a few examples that could be multiplied were we to fully evidence this overaccountability practice.

The essence of our governance is to account for all the how-to's in contrast to "what" the laboratories contribute.

As a consequence the system is rife with:

-Hundreds of full-time equivalents are attending to issues per laboratory to see to the meeting of DOE requirements that are in excess of Federal, state and local regulations and/or are in excess of requirements for a comparable, commercial activity

-Hundreds of thousands of pages of budget information documents are prepared and circulated throughout the system. Many of the laboratories find themselves submitting their budget documents to well over one hundred offices.

-Department of Energy orders to the laboratories range from a few to a few hundred pages in length and are prescriptive to detail processes

-There are some 30 thousand individual requirements embodied in these orders to certain of the major laboratories

-Once an individual order has been determined as obliged to resolve a particular situation it is more often then spread universally throughout the system without any differentiation as to the uniqueness of the initial concern. For example an employee of a contractor only indirectly related to the principal work of a laboratory was involved in an automobile accident. This generated a prescription that all employees who drive their vehicle on laboratory affairs were obliged to take defensive driving lessons with the consumption of an inordinate number of hours and excessive dollars in unnecessary training costs.

-Auditors and inspectors often by the dozens descend often daily on many of the laboratories. The laboratories have to staff up to be responsive to the engagement and then are obliged to spend a significant amount of time putting in place whatever are the prescriptions of these auditors. Virtually every audit that was accounted to the Task Force added a cost, versus saved a cost.

-Almost everyone must follow new rules and orders not necessarily relevant to their situation, if perchance a few have erred elsewhere.

-DOE Headquarters has insisted that copies of DOE terms and conditions be attached to all file copies of literally thousands of small purchase orders in order to document that these terms and conditions had been transmitted to vendors.

-Procurement management directives have obliged the hiring of additional support staff, vastly increasing written procedures and hiring of procurement consultants.

-Construction projects and operational and equipment activities are to be managed to various different tracks of regulations complicating the common sense approach to resolving the particulars of such functions way beyond what other institutions in society bear.

-The capital asset management process and condition assessment survey is a hornet's nest of complex documentation without cost benefit consequences.

-Senior audit and inspection officials state that they must concentrate on reviewing and insisting on processes, audits, etc. because there is to them little demonstrated "product" against which to evaluate if the labs are producing a knowledge value for the money appropriated. Process is a surrogate of product.

-Department of Energy people report that many Congressmen believe that the Department of Energy should treat the oversight of employees of the private contractors just as if they were employees of the government.

-More controls are in the offing regarding overtime, pension costs and decisions regarding make or buy.

-From time to time the Congress or the Department allocates funds for a general research program and then put fences around what the money can be spent for.

-Congress and the Department often specify what it wants done but does not allocate the money for that new additional function.

-Funds are segmented to what are colloquially called "stove pipes" whereas the aggregation of funds would be far more effective and efficient allowing the people who know what the technology is all about to work out the allocations.

-Consortia are a recommended institutional way of the private sector interfacing with the laboratories. AMTEX (American TEXtiles) is one such consortia. It took scores and scores of CRADAs to be written in order to have a relationship with the one consortia. Certain consortia that would want its work done most effectively in the laboratory system cannot get the work done in the appropriate laboratory.

-The system is input oriented versus output oriented.

-Each laboratory acknowledges that it has more people than it needs because of the Federal prescriptions and the inability to add the flexibility of assigning people in the manner that would be most productive.

-Environmental, safety and health objectives are worthy and all reasonable ones should be accomplished. The degree to which the Government is specifying how these are to be handled is beginning to absorb virtually as much funds as funds remaining for science.

-A laboratory wanted to outsource its cafeteria service. The Government obliged that the outsourcing of the 22 cafeteria workers required the laboratory to write a complete workforce restructuring plan, in spite of the fact that the authorizing act for such was intended to deal with fundamental structuring or changes in missions versus a minor change in a department. Incidentally, all of the 22 people would have been candidates to work for the outside supplier if that were to their and the supplier's best interest.

-Everyone wants in on the act--headquarters, the DOE area office, the DOE field office, program offices of the DOE, the Defense Nuclear Facilities Safety Board (DNFSB), the Department of Labor's office of Federal Contract Compliance, the EPA, the General Accounting Office (GAO) and the state where the lab is located. Each has oversight entities. Each thinks that their audit is the most important. Most audit without any coordination with others. Some audits take as long as six months. The number of auditors in an audit team vary greatly but has been as high as 150 people. The major financial impact of this is not the cost of the auditor's time but the cost and lost productivity of those interfacing with the auditors. This leads to an enormous escalation of cost. Possibly the greatest negative effect is the affect on the motivation of the scientists and engineers, all of whom are loyal to their science and loyal citizens wanting to be able peers with their respected associates in the laboratory. But we heard from any number of people the message that can be simply summarized that "more and more of us are more concerned about our job than doing the job." Too much time is distracted to the unpleasant and unproductive aspects of the job. An increasing number, though still a minority, lean to questioning the conditions of the job. Good people are leaving.

-The Department of Energy acknowledges that waste management and environmental remediation programs are the most rapidly growing Department of Energy demand on funds. To the extent that these obligations which derive from defense functions of decades ago could be more clearly segmented, the other major future interests including new science for environmental subjects, could stand alone.

-Starts and stops of assignments have caused an inordinate unproductive waste of funds. For example, the mesas around Los Alamos are strewn with the skeletons of facilities that were started with much enthusiasm on the part of the laboratory, the Department of Energy and Congress but were prematurely terminated before completion because the annual funding appropriation could not be sustained. Often these projects were more than 75 percent complete at the point of cancellation. The annual

programming of funds is a major waste. Multiyear programming should in some fashion be accomplishable, providing the confidence of predictability.

-The very process of annually having to resell a program is an act of inefficiency.

-The total laboratory program (10 laboratories, $6 billion budget, 17 thousand active R&D personnel, etc.) is modest in size compared to many of the large corporations. Any corporation that you would compare this to would have but a small fraction of audit costs compared to what is involved in the oversight of the DOE laboratories. The laboratories are run by the same high quality class of honorable people (though they, like corporate people, make an occasional mistake or misallocation) and do not need to be overseen in the fashion that is prescribed. Those in the private sector rarely audit and inspect their suppliers' business processes, and for the most part no corporation allows any of its customers to audit and inspect its activities. The private sector does respect the laws that apply specifically to financial accounts, safety factors, etc., and the government laboratories should be limited to the same class of oversight.

-Recently the Department has been engaged in a sincere interest to improve the contracting process aimed at having the contracts be performance-based. Yet in the first major paragraph of the news announcement concerning performance-based management contracting, it says "the reforms would increase competition for DOE business, hold contractors more accountable for fines and penalties, reduce excessive outside attorney fees, require a specific performance criteria and measures on all contracts, impose stricter cost controls on expenses such as administrative support, maintenance, pensions, overtime and property management." The document that explains the performance-based contract is scores and scores of pages long.

-Page 46 of the contract explanation document indicates that the Department's current information system does not provide the kind of data needed to manage contractors effectively. The words convey: the Department wants to manage.

-The document pleads the case that all the various contract administrators, inspector generals, audit agencies, etc. are under staffed and need more people.

-There has been an avalanche of DOE orders including 4,800 project orders and 8,400 Environment, Safety and Health (ES&H) orders with from 200-400 oversight reviews per lab per year.

-There are at least 12 principal layers of management between the assistant secretary for defense programs down through the layers of DOE and the laboratory program management to the bench scientist working of a project financed through defense programs. There are additional oversight and administrative chain of commands through the field offices which probably add two or three more layers.

-One array of difficulties with which DOE has not yet been able to deal properly is ironically self-inflicted. Far too much influence has been ceded to non-regulatory advisory boards, such as the Defense Nuclear Facilities Safety Board (DNFSB). Such organizations generate recommendations with no apparent cost / benefit analysis, resulting in significant unnecessary expenditures and productivity losses.

-There is neither a mechanism within DOE to evaluate and stand against poorly-taken DNFSB edicts nor to ensure Department-wide compliance with those edicts judged appropriate. The Board has itself noted this last defect.

-At Pacific Northwest Laboratory, for example, overhead costs of Environmental Safety and Health (ES&H) increased 40% over a four year period with no demonstrable improvement. A study of 13 DOE labs indicated that ES&H funding increased 100% and manpower increased 50% between 1985 and 1990. Safety performance was independent of funding and negative indicators (lost work days, radiation exposure, etc.) remained constant or increased.

-In many areas the regulations parallel rules already enforced by agencies outside of DOE under federal and state legislation. Frequently they prove unnecessarily stringent. As an example: Radiological control of radiation sources at Lawrence Livermore National Laboratory requires sources 100 times smaller than a Coleman lantern mantle and 300 times smaller than a smoke detector to be treated under the same standards as larger sources.

-EG&G, the management and operations (M&O) contractor at Rocky Flats, recently spent about $500,000 to write a record of decision to document that no further action was required to close out one of the Individual Hazardous Substance Sites (Operable Unit #16), mostly free of

mixed waste contamination, where no further pumping or digging was needed.

-This was the result of an environmental gridlock involving the Comprehensive Environmental Response, Compenstation, and Liability Act (CERCLA), the Environmental Protection Agency (EPA) and the Colorado Dept. of Health, which DOE was unable to resolve.

-Requirements for maintaining the "safety envelope" at the Rocky Flats site, which among other matters involves 245,000 surveillances annually, preparing inspection reports and maintenance improvement records, costs the plant $100 million per year, a level that senior management considers "very unreasonable." Many staff members echo the desire for a clarification of goals for the site. Moreover while the delays mount, the experience base continues to degrade as seasoned employees retire or quit.

## Appendix B: If GOCO System Is Obliged

If the authorities oblige that the GOCO system is retained, the Congress and the Department must improve operational efficiencies and motivational conditions of the federal system by correcting the policies and practices listed below. If these are not completely revised the Congress/Department/Laboratory system is destined to bear excessive unaffordable, micromanaging costs and demotivational consequences. It will follow that plan to deactivate and/or dispose of the laboratories at some liquidation value will be inevitable because the public will not countenance the high cost/low value output that will be destined.

### Base DOE Oversight on Laboratories' Performance

-Replace compliance-based directives with simple, well-defined performance measures.

-Eliminate DOE approval of labs' internal procedure documents.

-Eliminate DOE approval of individual transactions (e.g., in procurement and compensation).

-Base audits and appraisals on serious risk.

-Eliminate duplication of audits, appraisals, and reviews.

-Reward success with decreased oversight.

Operate labs according to industry-wide regulatory standards

-Eliminate DOE self-regulation.

-Shift regulatory oversight and inspection functions to responsible federal agency.

-Eliminate these functions in DOE and reallocate resources.

### Consolidate roles of DOE oversight offices

-Consolidate fragmented headquarters safety roles and responsibilities.

-Reduce vertical layering of responsibilities for general lab oversight.

- Delegate oversight to one contracting office per lab, with a well-defined, limited scope of authority.

-Consolidate or eliminate field offices, at least.

**Apply rational, consistent business management principles**

-Institute a multiyear budget process, for both authorization and appropriation.

-Standardize DOE's budgeting and financial reporting requirements across program offices:

- Offices have different criteria for schedule, format, type of budget data, or type of cost reporting.
- Cross-cut budgeting should be examined for appropriateness.

-Empower labs to establish long-term supplier relationships.

-Empower labs to locally determine "color of money", except for Congressional mandates.

**Manage lab infrastructure in a responsible fashion**

-Re-establish a strong, well-defined landlord function, with one landlord per lab.

-Consolidate funding sources for infrastructure maintenance and improvement with each lab's DOE landlord.

-Initiate a multiyear "get well" program for labs' infrastructures.

**Challenge labs to reduce costs**

-Allow the quality management programs to become fully applied without outside interference.

-Strengthen overhead-control efforts.

-Outsource work based on good business practice for each site.

-Re-engineer administrative processes to fully exploit benefits of modern information systems.

**Other**

-Simplify CRADAs much more.

## Appendix C: Terms of Reference

### Terms of Reference
### Secretary of Energy Advisory Board Task Force on
### Alternative Futures for the Department of Energy National Laboratories

Overview

The 1990s are a period of substantial change for the Department of Energy's (DOE) nine multi-program National Laboratories, particularly the Department's three nuclear weapons laboratories. Sweeping geopolitical changes, limitations on nuclear weapons testing, increased attention to economic competitiveness, and the continuing demands of energy development and environmental quality--all within the context of tight federal budgets--are but a few of the factors that confront the DOE laboratories with challenges and opportunities for the future.

The purpose for establishing the Advisory Board Task Force on Alternative Futures for the DOE Laboratories is to carefully examine options for change within these laboratories and to propose specific alternatives for directing the scientific and engineering resources of these institutions toward the economic, environmental, defense, scientific, and energy needs of the nation. The Task Force should focus its initial efforts on developing a comprehensive and current understanding of the facilities, resources, core competencies, activities, and missions of the Department's multi-program national laboratories, both as individual institutions and as a system. The Task Force should also develop an early understanding of the national defense requirements that necessarily will play a major role in shaping the configuration of the defense laboratories for years to come, and should closely examine the unprecedented recent growth in collaborations between DOE laboratories and the private sector.

Once a fundamental understanding of these matters has been established, the Task Force should broadly explore critical issues facing DOE's multiprogram laboratories (and single-program laboratories, as deemed appropriate) and should examine alternative scenarios for future utilization of these laboratories for meeting national missions. Among the alternative scenarios, the Task Force should specifically address options involving the possible redirection, restructuring, and/or closure of elements of the DOE laboratory system. The Task Force should identify the costs and benefits to the nation of various alternative futures for the DOE multiprogram laboratories, and within one year (January 1995) should report these assessments along with recommendations, as deemed appropriate.

Objectives

1. The Task Force should develop a clear understanding of the roles played by the DOE multi-program laboratories in the research and technology development process. Specifically, the Task Force should examine the roles of the laboratories in meeting public missions, in serving as an R&D provider to other agencies and the private sector, and in working with academia to advance fundamental science. This examination should include an assessment of the contribution of the DOE laboratory system to the overall national investment in science and technology, and a comparison of the activities of the DOE laboratories to the R&D focus of other government agencies, academia, and the private sector.

2. The Task Force should become well versed with the nuclear weapons-related research, development, testing, and evaluation (RDT&E) needs for the nation over the coming decade, and the options for satisfying these needs. Specifically, the Task Force should closely examine the strategic planning efforts currently underway within DOE Defense Programs, particularly those efforts aimed at shifting the nuclear weapons safeguards program from underground nuclear testing to science-based stockpile stewardship.

3. The Task Force should examine the current configuration of nuclear weapons RDT&E activities among Los Alamos National Laboratory, Livermore National Laboratory, and Sandia National Laboratories. This should include an assessment of the strategy behind the current configuration, which involves purposeful redundancy to promote competition and peer review. Alternatives to the existing configuration should be examined.

4. The Task Force should assess the role of the National Laboratories in supporting economic competitiveness and contributing to the U.S. industrial R&D base. This should include an examination of the opportunities and the mechanisms for the National Laboratories--as a system--to contribute to large partnerships with the private sector.

5. With a current assessment of the roles and missions of the DOE multiprogram laboratories in mind, the Task Force should examine several options for the future of these institutions in terms of budgets, management, and mission assignments, including an analysis of possible costs and benefits of each alternative. As part of the examination of costs and benefits, the Task Force should assess the ability of R&D institutions such as the DOE laboratories to adapt to varying levels of change. This analysis should assist the Task Force in recommending implementation options.

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