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The Impact of Recent Constraints on Intellectual Freedom on Science and Technology at the Lawrence Livermore National Laboratory

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Introduction

The Lawrence Livermore National Laboratory (LLNL) was created in 1952 to meet the nation's need for an expanded nuclear weapons research and development (R&D) capability. LLNL quickly grew to become a full-fledged nuclear weapons design laboratory with a broad range of technical capabilities similar to those of our sister laboratory — Los Alamos — with which we shared mission responsibilities. By its very nature, nuclear weapons R&D requires some of the most advanced science and technology (S&T). Accordingly, there is an obvious need for careful attention to ensure that appropriate security measures exist to deal with the sensitive aspects of nuclear weapons development. The trade-off between advancing S&T at the Laboratory and the need for security is a complex issue that has always been with us. As Edward Teller noted in a recent commentary in a May, 1999 editorial in the *New York Times*:

The reaction of President Harry Truman to the leaking of information is well known. He imposed no additional measures for security. Instead, we have clear knowledge that the disclosures by (Klaus) Fuchs caused Truman to call for accelerated work on all aspects of nuclear weapons.

...The right prescription for safety is not reaction to dangers that are arising, but rather action leading to more knowledge and, one hopes, toward positive interaction between nations.

To explore the issue of intellectual freedom at a national security laboratory such as LLNL, one must understand the type of activities we pursue and how our research portfolio has evolved since the Laboratory was established. Our mission affects the workforce skills, capabilities, and security measures that the Laboratory requires. The national security needs of the U.S. have evolved, along with the S&T community in which the Laboratory resides and to which it contributes. These factors give rise to a greater need for the Laboratory to interact with universities, industry, and other national laboratories. Intellectual freedom at the Laboratory and constraints on it can be understood only within the context of our mission, our necessary interactions with other entities, and our need for an exceptional multidisciplinary workforce.

Issues of Intellectual Freedom at LLNL

The significance of intellectual freedom to a scientist or engineer is similar to that of freedom of speech. Their freedom is constrained only by intellectual honesty and the rigors of the scientific method, scientists and engineers have the right and responsibility to publish the results of their research and comment on the public policy implications of their work. For national security research, classification is further a constraint, but one for which those doing classified work have learned to live with through long-practiced classification procedures established by the Atomic Energy Act in 1954. Like freedom of speech, intellectual freedom has generally well-understood boundaries of acceptable behavior. Just as one's freedom of speech is limited by responsibility for the consequences (e. g., shouting "Fire!" in a crowded theater), Laboratory employees, in general, intentionally do not divulge classified information.

As conceived by most Laboratory researchers, intellectual freedom has two other key components: (1) the latitude to follow their scientific instincts to pursue exploratory research that supports mission goals, and (2) unrestricted (except for classified) communication with other researchers with common interests. It is in these two areas that Laboratory employees can feel most constrained in their intellectual freedom.

Historically, employees have felt limitations on their flexibility to pursue exploratory research most strongly at times when budgets were very tight (e.g., post-Vietnam War and after the Cold War before the inception of the Stockpile Stewardship Program). Another factor affecting research flexibility is the growing tendency of sponsors to take a piecemeal, specific-task-oriented approach to funding research.

Unrestricted communication with other researchers who have common interests arises particularly for Laboratory employees working on unclassified projects; this work nowadays includes a sizeable fraction of our national security research. In many cases the very success of our R&D endeavors depends on extensive collaboration and communication with scientists and engineers in academia, industry, and other national laboratories.

In regard to intellectual freedom versus security issues, our cooperative efforts with others are important from at least two perspectives. First of all, we work fairly routinely with non-national-security laboratories as well as with universities and industry. Clearly, the security requirements at those sites are quite different than ours. Secondly, interactions with all those outside the national security laboratories raise the complex issue of interactions with foreign nationals, from both "sensitive" and "non-sensitive" countries. These issues are not only relevant to our interactions with others but are also relevant to our own workforce.

The Laboratory's Mission

Along with Los Alamos and Sandia national laboratories, Lawrence Livermore is a premier applied-science national security laboratory — not just a weapons laboratory. In the most succinct terms, the mission of LLNL is:

To ensure national security and apply S&T to the important problems of our time.

A more comprehensive mission statement is:

- Lawrence Livermore National Laboratory is a premier applied-science national security laboratory.
- Our primary mission is to ensure that the nation's nuclear weapons remain safe, secure, and reliable and to prevent the spread and use of nuclear weapons worldwide.
- This mission enables our programs in advanced defense technologies, energy, environment, biosciences, and basic science to apply Livermore's unique capabilities, and to enhance the competencies needed for our national security mission.
- The Laboratory serves as a resource to U.S. Government and a partner with industry and academia.

Clearly from our mission statement the Laboratory engages in diverse S&T areas that may appear to be outside the national security aegis. This approach to research is the legacy of Ernest O. Lawrence, for whom LLNL is named. Lawrence's model was one of "team science" — large projects of national importance that require a multidisciplinary approach. That is our heritage — of which we are most proud. Major consequences of Lawrence's approach were the development of unique capabilities at the Laboratory, our use of multidisciplinary teams to tackle challenging problems, and a deep-seated partnership with the University of California (UC).

At its inception, LLNL focused almost exclusively on nuclear weapons. Our primary mission remains national security, which accounts for about 80% of our budget. However, our national security activities have not only changed significantly since 1952, but have also broadened, particularly since the end of the Cold War. The original nuclear weapons mission — designing and engineering new weapons for the stockpile that are more militarily effective and safer — has evolved to the Stockpile Stewardship Program, which accounts for about 50% of our budget. It is a science-based effort to maintain the stockpile in the absence of nuclear testing. With an emphasis on developing a fundamental scientific understanding of weapons-performance issues, such as the aging of

materials, we are interacting with the academic community even more than we have in the past. Furthermore, the national security challenges are now broader, having evolved to a level of about 30% of our budget that includes areas such as nonproliferation, arms control, and work for the Department of Defense (DoD).

About 20% of our research portfolio is in other mission areas that build on the core capabilities and unique facilities needed for our national security mission. These include efforts to meet important national needs in energy, environment, and the biosciences. A few examples illustrate how Lawrence's basic model — use of multidisciplinary teams of scientists and engineers to tackle significant problems — has led to the Laboratory's current programmatic base and diverse scientific accomplishments.

- **Energy:** Our interest in thermonuclear weapons led to our interest in fusion science, with the ultimate goal of fusion for civilian energy. In addition to our work on magnetic confinement fusion, LLNL took the lead in pursuing inertial confinement fusion and large glass lasers for that purpose. We hope to achieve fusion ignition and burn in the National Ignition Facility (NIF), which is currently under construction at LLNL.
- **Environmental Sciences:** Through the Cold War, the Laboratory conducted nuclear tests, at first in the atmosphere and then underground. Accordingly, we developed expertise in atmospheric and earth sciences to understand and to limit the effects of these tests. Our atmospheric science expertise led to the establishment of the National Atmospheric Release Advisory Center, which provides real-time information for emergency response in the event of an atmospheric release of radioactive or toxic materials (such as the Chernobyl event in 1986 and the Mt. Pinatubo explosion in 1991). We are also a major contributor to international efforts to model climate change and are home to the Program for Climate Model Diagnosis and Intercomparison. Our geoscience expertise is contributing to the Yucca Mountain Project to dispose of nuclear wastes and to efforts to improve technical capabilities to monitor an international ban on nuclear testing.
- **Bioscience:** Our studies of the biological effects of ionizing radiation resulted in the development of fast-flow cytometry and other technologies that led to DOE's Human Genome Initiative in 1987 and LLNL's participation in the Human Genome Project. Our expertise in genomics and biotechnology is now enabling us to pursue functional genomics and to develop fast, portable, biological-agent detectors for nonproliferation applications.
- **Other areas of science such as astrophysics:** The Laboratory's interests in astrophysics stem from expertise in high-energy-density physics and capabilities to develop advanced instrumentation. In the 1990s, LLNL researchers discovered Massive Compact Halo Objects (MACHOs) in the search for "missing mass" in the universe, developed the sensor suite for Clementine (which collected over 1.7 million images while orbiting the

Moon), created metallic hydrogen in a laboratory setting, and developed laser guide-star adaptive optics to improve images from terrestrial telescopes.

These examples, and many others not mentioned, illustrate that even with a primary focus of national security, LLNL scientists and engineers have special expertise that enables them to make scientific discoveries and develop technologies in fields not directly tied to nuclear weapons. Our mission is broader than nuclear weapons, and we cannot accomplish our mission in isolation from the broader scientific and technical community.

Interactions with Universities, Industry, and Other Laboratories

To execute the nuclear weapons program, along with our broader national security mission and other research activities, LLNL has always worked with other laboratories, industry, and universities. Through these interactions, the Laboratory contributes its special expertise to advance S&T, and we draw upon the best that others have to offer to ensure that our national security efforts stay on the cutting edge of what is possible.

With the University of California and Other Universities

LLNL has been part of the UC since the Laboratory's inception. This special relationship is deeply ingrained in our culture. An almost inevitable finding of every review of UC's management of its DOE laboratories has been the importance of the UC connection for maintaining intellectual freedom:

It is of the utmost importance that the U.S. retain, in the crucial and controversial area affecting nuclear deterrence, people who are at once technically outstanding and as independent as possible from bureaucratic and political restraints on the expression of unpopular views.

(Buchsbaum Report to the DOE, 1979)

[The Council] believes that it is critical that the Laboratories continue to be defined by the highest standards of scientific quality and by other more elusive, but no less important, characteristics, such as openness, scientific freedom, and independence.

(UC President's Council on the National Laboratories, Report, 1996)

Preservation of the academic atmosphere at the Laboratories is a cornerstone to the UC/DOE contract.

(UC President's Report to the UC Regents, 1997)

LLNL's ties to UC go beyond the UC President's Office management and oversight. Since our beginning, our relationship with UC has evolved steadily — from a series of informal, individual contacts between our employees and UC faculty to extensive research collaborations with virtually every UC campus. In particular, five LLNL-UC Research Institutes are on site at Livermore that focus on research areas where expertise is needed to execute Laboratory programs. They provide a hospitable working environment for visiting students,

postdoctoral fellows, and faculty as they work with Laboratory researchers on collaborative projects. In addition, the Department of Applied Science of UC Davis has facilities at Livermore, and recently the Laboratory has signed a Memorandum of Understanding with the new UC Merced, the tenth UC campus and the first new research university of the 21st Century. We expect that UC Merced will become an important partner in joint research activities and a future source of high-caliber employees.

The Laboratory also maintains extensive collaborative relationships with many other universities. As in the case with UC, these collaborations strengthen the research programs at LLNL and serve as a vehicle for recruiting new talent. One prominent example of our academic collaborations is the Academic Strategic Alliances Program (ASAP), a \$250 million initiative that forms part of the Accelerated Strategic Computing Initiative (ASCI) to help meet the computing goals of the Stockpile Stewardship Program. ASAP is engaging the best minds in the U.S. academic community — which includes foreign nationals—to accelerate the emergence of new unclassified simulation science and methodology and associated supporting technology.

Our many partnerships with universities have also yielded important scientific benefits to our programs. An excellent example is the Massive Compact Halo Objects (MACHO) Project, an experimental search for the dark matter that makes up at least 95% of the mass of our galaxy. In addition to the University of Washington, Notre Dame, and UC San Diego, our partners include the Mt. Stromlo Observatory in Australia, McMaster University in Canada, Oxford University in England, and the European Southern Observatory in Chile.

With Industry

We have always partnered with U.S. industry to obtain capabilities we need for our weapons program. The most notable example is in the area of computers — from the Laboratory's acquisition of a Univac in 1953 to our current participation in DOE's ASCI program and the delivery this year of a 12 teraops (12 trillion operations per second) supercomputer from IBM. ASCI relies on the computer industry not as a mere supplier but as a true partner in developing what will ultimately be a series of 100 teraops computers, with the associated software and memory requirements. Similarly, construction of the NIF, the largest laser in the world, has a vital reliance on industry partners, as have our past efforts designing and building successively larger laser systems from Shiva to Nova.

Our interactions with industry have evolved, particularly since the end of the Cold War, to include other elements, for example direct support to the Laboratory by industrial consortia (e.g., the Extreme Ultraviolet Lithography program) and transfer of technology by commercialization in the private sector. Areas such as environmental remediation and health care provide examples of LLNL-developed technologies that we "spin off" for public benefit through mechanisms such as cooperative research and development agreements

(CRADAs) and licensing. The Laboratory has been particularly successful in the arena of industrial partnering, although success at times creates controversy. Issues that arise center around competition with the private sector as well as export control and foreign company involvement.

Naturally, LLNL benefits from interacting with industry to access new S&T. Industry funds more R&D than the combination of the federal government, universities and colleges, federally-funded research and development centers, and nonprofits. Industrial globalization means that foreign involvement is inevitable. The very concept of what constitutes a "U.S. company" is reflected in the fact that over 50% of Ford and IBM employees are located outside the U.S. Furthermore, the current U.S. spending on R&D is less than the total R&D spending in the other G7 countries (Japan, Germany, France, UK, Italy, and Canada). These data imply that for the Laboratory to isolate itself from industry and ignore foreign R&D is not a viable option. But we must deal with the security implications.

With Other Laboratories

Work with other laboratories is vital to the execution of LLNL's portfolio. Indeed the history of such interactions has its roots in the early competition and collaboration with Los Alamos. Through competition we improved the performance and safety of weapons in the U.S. nuclear weapons stockpile throughout the Cold War; and through collaboration we advanced the S&T base for nuclear weapons, which is especially important now that we no longer conduct nuclear tests. The Stockpile Stewardship Program is a highly collaborative effort that makes use of the unique capabilities at each of the DOE national security laboratories, the Nevada Test Site, and the production sites within the DOE nuclear weapons complex. The Program also draws on many sources of external expertise.

LLNL has joint programs with nearly all of the major laboratories in the U.S. as well as with most prominent foreign laboratories such as Atomic Weapons Establishment in the UK and Commissariat à l'Énergie Atomique (CEA) research centers in France. Through a variety of lab-to-lab programs, we also work with scientists at the nuclear weapons research laboratories in the former Soviet Union. Examples of partnerships include our work with Lawrence Berkeley National Laboratory and Stanford Linear Accelerator Center on the B-Factor and the Next Linear Collider; the Joint Genome Institute, which involves Berkeley and Los Alamos national laboratories; and our work with CEA in France and others on the NIF. Many other collaborative research efforts in energy, environment, and bioscience could be cited as well.

Our Exceptional Workforce — Current Challenges

To achieve the challenging goals of our mission areas, LLNL and the other national-security laboratories have always sought the best possible scientists and

engineers, and they have historically been able to attract a workforce of exceptional quality. This high-quality staff has kept us at the forefront of R&D within the nation.

Several key factors have contributed greatly to attracting exceptional people to these national laboratories:

1. **A mission and a vision:** historically the laboratories have enjoyed a national commitment to, and appreciation of, our national security mission, as well as a clear vision of our role in making the world a safer place through S&T.
2. **Work excitement:** R&D of national importance, with the flexibility to focus efforts from exploratory research to advanced development according to project needs,
3. **Work environment:** an environment for conducting world-renowned research, a reputation for excellence, and a competitive compensation and benefit package for employees.

Adverse trends in each of these areas were accentuated by recent security-related events and actions in response to those events, which resulted in a difficult environment for the laboratories in 1999. Data indicate that our ability to attract and retain a quality workforce has suffered as a result — we hope not irreparably.

Last year was a particularly difficult year for the Laboratory in terms of recruitment and retention. The nominal annual attrition rate at LLNL has been extremely low, at about 2% for recent years. However, over the last year, it has risen to about 7%, more than three times the usual rate, though this rate would be considered low in some industry sectors. Even more concerning than the abnormally high average attrition rate is the extremely high attrition rate — up to 20% — in key areas such as computing and selected engineering fields. Concurrently, the overall acceptance rate for job offers has dropped from 85% to about 65%.

The negative impact is not the result of a single issue, such as compensation or a decline in intellectual freedom, but a collection of factors. To reverse these adverse trends, we are taking a number of tactical actions.

Recruiting

We have established changes in hiring practices, e.g., targeted salary areas, cash awards, sign-on bonuses, on-the-spot hires, etc. We have also instituted the prestigious Lawrence Postdoctoral Fellowship Program and other postdoctoral programs. It is worth noting that between 50% to 75% of applicants for these Lawrence Fellowships are foreign nationals.

Retention

In the area of retention, we created a number of new programs at the Laboratory to provide additional incentives for our scientific leaders and future managers. For example, in 2000 we began the Edward Teller Fellowship Program that is comprised of "MacArthur"-type awards presented to individual scientists who have made significant accomplishments in their field. The award allows them to continue to pursue research unconstrained by their normal programmatic responsibilities. In addition, the Long Range Strategy Project group was formed with 22 of our mid-career scientists and engineers who spent 18 months exploring what the Laboratory will look like in the year 2020.

In addition to the above tactical areas, strategic areas where the DOE national security laboratories need help to reverse the attrition trend. In many cases, these areas relate to specific events and changes at the laboratories that happened last year, and tie directly or indirectly to the issue of intellectual freedom versus security.

Recent Security Measures and Changes and Their Effect on Intellectual Freedom

In 1999, a number of reactive responses to security events and other actions were taken that affected the workplace at LLNL. While it seems apparent that these factors have had an impact on recruiting and retaining employees, (at least in the short term), it is difficult to discern their impact on intellectual freedom. These security measures and changes include:

- **The threat of wide-spread use of polygraphs:** It is unclear how polygraph testing of LLNL personnel will ensure security. However, it is clear that the reaction of employees within the Laboratory has been very negative. While the scope and extent of the testing remains uncertain, the threat of polygraph testing has led in a few cases to scientists and engineers requesting reassignment.
- **Increased attention to managing "export sensitive" information:** Laboratory employees, many of whom are engaged in efforts to stem the proliferation of weapons of mass destruction, are diligent in protecting information that could be helpful to potential adversaries. However, when the definition of what is sensitive and what is not remains ambiguous, bureaucracies tend to act conservatively, resulting in excessive restrictions on information dissemination and unnecessary paperwork. Additionally, the standards for handling sensitive information often differ, for example, between DOE's national security laboratories and its science laboratories. These issues, which have a broader impact than just DOE, are beginning to sort themselves out. The long-term effect will be additional paperwork and costs, and likely additional restrictions on information dissemination, with a possible loss of intellectual freedom.

- **Restrictions on interactions with foreign nationals within and outside the Laboratory:** Within the Laboratory, cyber security concerns are limiting the access foreign nationals have to our most powerful computers. In addition, the past year has witnessed a moratorium on visits of sensitive-country foreign nationals to the DOE national security laboratories (unless permission was granted by exception). That moratorium has been lifted, but foreign trips by LLNL personnel and visits by foreign nationals to the Laboratory still undergo very careful scrutiny. Unfortunately, this results in foreign visitors often feeling unwelcome, even in unclassified areas of the Laboratory, due to the cumbersome steps that must be followed to arrange the visit and the restrictions to which visitors are subjected while they are here.
- **Reductions in Laboratory-Directed Research and Development (LDRD):** For FY 2000, LDRD at the DOE laboratories was reduced from 6% to 4% of the total budget. While this reduction did not directly restrain intellectual freedom, the large cut reduced LLNL's ability to conduct exploratory research, which is very important to our scientific and technological vitality. LDRD is also an important source of funding collaborative research efforts. In FY 2001, LDRD was restored by Congress to the 6% level. It is noted, however, that the time to restore lost capabilities, resulting from cuts of these types, greatly exceeds the time it took to create the lost capabilities.
- **Uncertainty in our continuing relationship with the University of California:** Our continuing relationship with UC, which is extremely important to Laboratory employees, appeared to be at grave risk last year. We are pleased that DOE Secretary Richardson recently announced that DOE will enter into negotiations with UC to extend the contract for three years.
- **Budget and program concerns:** In FY 2000, LLNL employees were especially concerned about the future of major programs at the Laboratory, including the NIF, the future of ASCI at LLNL beyond the 12 teraops machine just delivered, and funding for and our role in the Stockpile Stewardship Program. At least for the time being, these issues now seem to be behind us. A rebaselined program for the construction of NIF has been approved by DOE and funded by Congress, and we continue construction of the Terascale Simulation Facility at Livermore, which will house a next-generation ASCI supercomputer (60 to 100 teraops).

Although 1999 was a difficult year, improvements have been steady. Though there is cause for optimism, not all issues will be cleanly resolved and the Laboratory will continue to feel the impact from these issues on intellectual freedom and the latitude to pursue cutting-edge research within the Laboratory and with a wide range of external partners.

In addition, the Laboratory would benefit greatly from a reaffirmation of our mission and vision. The National Nuclear Security Administration (NNSA)

within DOE and the national security laboratories have an important mission and also require adequate funding to pursue fundamental science to get the job done. By strengthening the basic Laboratory tenets of intellectual freedom—the latitude to undertake research activities that support Laboratory missions and the continuing ability to interact with the international science community—we will ensure the health of the Laboratory and the continued excellence of its workforce.

Summary

The DOE national security laboratories have effectively managed the pursuit of S&T in a secure environment for half a century. We are an integral part of the international S&T community, and we depend on interactions with others to sustain the quality of our programs by ensuring that our work is at the cutting edge of what is possible. For Laboratory employees, intellectual freedom means having the latitude to pursue exploratory research, open communication with other researchers, and the right to publish their research results.

As White House Science Advisor Neal Lane said in his address entitled “The New Security Environment” to the National Academy’s forum on “Scientific Communication and National Security” (October 6, 2000):

... History clearly shows that we rely on science to ensure our security, not to mention our economy and our whole way of life. But at the same time, we certainly cannot reap the benefits of that science unless our national security is secured. Let me first make three assertions:

- National security requires scientific excellence;
- Scientific excellence requires openness; and
- Openness is inherently international.”

Today we are facing real challenges. Compared to the past, our mission requires us to engage in ever closer and more extensive interactions with universities, other laboratories, and industry. And S&T — as well as the Laboratory’s workforce — has grown more international. Unfortunately, recent events have triggered actions and some over-reactions to tighten security. The result has been a difficult year with attendant challenges in recruiting and retaining personnel and possibly some limitations on intellectual freedom. As we find less onerous ways to implement enhanced security at the laboratories, we continue our efforts to reduce some of these limitations on intellectual freedom and to foster a work environment that is conducive to leading-edge research.

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