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In Defense of the National Labs and Big-Budget Science

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IN DEFENSE OF THE NATIONAL LABS AND BIG-BUDGET SCIENCE

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The purpose of this paper is to present the unofficial and unsanctioned opinions of a Visiting Scientist at Lawrence Livermore National Laboratory on the values of LLNL and the other National Labs.

The basic founding value and goal of the National Labs is big-budget scientific research, along with smaller-budget scientific research that cannot easily be done elsewhere. The most important example in the latter category is classified defense-related research.

The historical guiding light here is the Manhattan Project. This endeavor was unique in human history, and might remain so. The scientific expertise and wealth of an entire nation was tapped in a project that was huge beyond reckoning, with no advance guarantee of success. It was in many respects a clash of scientific titans, with a large supporting cast, collaborating toward a single well-defined goal. Never had scientists received so much respect, so much money, and so much intellectual freedom to pursue scientific progress. And never was the gap between theory and implementation so rapidly narrowed, with results that changed the world. Completely.

Enormous resources are spent at the national or international level on large-scale scientific projects. LLNL has the most powerful computer in the world, Blue Gene/L. (Oops, Los Alamos just seized the title with Roadrunner; such titles regularly change hands.) LLNL also has the largest laser in the world, the National Ignition Facility (NIF). Lawrence Berkeley National Lab (LBNL) has the most powerful microscope in the world. Not only is it beyond the resources of most large corporations to make such expenditures, but the risk exceeds the possible rewards for those corporations that could.

Nor can most small countries afford to finance large scientific projects, and not even the richest can afford largess, especially if Congress is under major budget pressure. Some big-budget research efforts are funded by international consortiums, such as the Large Hadron Collider (LHC) at CERN, and the International Tokamak Experimental Reactor (ITER) in Cadarache, France, a magnetic-confinement fusion research project. The post-WWII histories of particle and fusion physics contain remarkable examples of both inter-national competition, with an emphasis on secrecy, and international cooperation, with an emphasis on shared knowledge and resources. Initiatives to share sometimes came from surprising directions.

Most large-scale scientific projects have potential defense applications. NIF certainly does; it is primarily designed to create small-scale fusion explosions. Blue Gene/L operates in part in service to NIF, and in part to various defense projects. The most important defense projects include stewardship of the national nuclear weapons stockpile, and the proposed redesign and replacement of those weapons with fewer, safer, more reliable, longer-lived, and less apocalyptic warheads. Many well-meaning people will consider the optimal lifetime of a nuclear weapon to be zero, but most thoughtful people, when asked how much longer they think this nation will require them, will ask for some time to think.

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NIF is also designed to create exothermic small-scale fusion explosions. The malapropos "exothermic" here is a convenience to cover a profusion of complexities, but the basic idea is that the explosions will create more recoverable energy than was used to create them. One can hope that the primary future benefits of success for NIF will be in cost-effective generation of electrical power through controlled small-scale fusion reactions, rather than in improved large-scale fusion explosions. Blue Gene/L also services climate research, genomic research, materials research, and a myriad of other computational problems that become more feasible, reliable, and precise the larger the number of computational nodes employed. Blue Gene/L has to be sited within a security complex for obvious reasons, but its value extends to the nation and the world.

There is a duality here between large-scale scientific research machines and the supercomputers used to model them. An astounding example is illustrated in a graph released by EFDA-JET, at Oxfordshire, UK, presently the largest operating magnetic-confinement fusion experiment. The graph shows plasma confinement times (an essential performance parameter) for all the major tokamaks in the international fusion program, over their existing lifetimes. The remarkable thing about the data is not so much confinement-time versus date or scale, but the fact that the data are given for both the computer model predictions and the actual experimental measurements, and the two are in phenomenal agreement over the extended range of scales.

Supercomputer models, sometimes operating with the intricacy of Schroedinger's equation at quantum physical scales, have become a costly but enormously cost-saving tool. Computer models of fusion reactions can be run with exquisite detail at speeds convenient for inquisitive human observers, without the inconvenience of vaporizing both experiment and observers. At NIF, for example, there are two collaborating teams; to oversimplify, one team runs the computer model, and the other runs the actual machine. It is usually cheaper to run a computer simulation of an experiment than the actual experiment, especially in the design stage. The supercomputer, however, is a voracious consumer of electrical power.

The defining duality at the Labs is between classified and unclassified research. This duality seeps through every pore and permeates to the heart. It provides the Labs with both their greatest powers and their greatest problems.

Los Alamos was free of the duality during the War -- everything was classified. After the War, the scientists who had been involved took a variety of positions. All had been deeply affected by what they had done. Many were fearful. After the first explosion (the Trinity test at White Sands), Oppenheimer responded by quoting Vishnu from the Bhagavad-Gita: "Now I am become Death, the destroyer of worlds." Although the devastations of Hiroshima and Nagasaki had been exceeded by the previous firebombings of other Japanese cities, everyone knew that a terrible genie had been released from the bottle.

There were some scientists who felt that the weapons should be turned over to an international government. Some felt that the United States should maintain secrecy, and try to retain supremacy if not exclusive possession. Almost everyone feared a nuclear arms race. Some wanted to continue the Manhattan Project at Los Alamos, perhaps to build a fusion bomb. It might seem paradoxical to work on a weapon that you hope will never be used, but it is not so different from a peacetime soldier training with his rifle, except, of course, for size. Oppenheimer himself suggested that most scientists should return to basic research, and pointed out that the Manhattan Project had depended on harvesting the fruits of previous basic research.

After the War, Los Alamos found itself at the forefront of a vibrant developing science -- nuclear physics -- and with a bunch of nuclear scientists who weren't sure what to do. Some looked to peaceful uses of the new science and technology, and some continued to work on bombs. The duality was born. As for the bombs, the one thing that can be said with certainty is that they have not been used again. There is a lively and impassioned debate about how best to maintain this, but very few think that universal possession is a viable way to go. Appropriately, the National Nuclear Security Labs today have programs, both classified and unclassified, on nuclear non-proliferation and reductions in existing weapons.

A duality exists in the fundamental motivations for the government to maintain the Labs, between what the Labs do and what the Labs might do. The second might be the more important. In the event of another crisis, a threat to the nation or even to humanity, the Lab stands prepared with both people and resources to be focused on the problem. The next time we should not have to create a new Manhattan project ex nihilo.

The current emergency over energy provides a timely example. Our energy sources are largely in the hands of nations who are arguably hostile or potentially hostile, and these resources are competed for by some nations who are arguably hostile or potentially hostile. This global struggle to see who gets to release the most carbon dioxide into the atmosphere also has long-term climatic consequences. The job of predicting these consequences has fallen partially on the National Labs, since they have and can devote the necessary computational resources, which will never quite be adequate. The scientific climatic predictions still have wide but narrowing variances, and, unfortunately, almost all of the variance bands contain outcomes which are seriously frightening.

The National Labs not only can advance our understanding of the forcing factors in climate and environmental change, but can analyze our options for responses, model the theories of various solutions, design and build experimental devices, and demonstrate feasibilities. These feasibilites are: scientific feasibility, technical feasibility, operational feasibility, and finally economic feasibility. The most hopeful solution to the energy crisis right now is fusion power, and, given the accuracy of the computer model predictions cited above, there is some confidence that scientific feasibility has been demonstrated. Moreover, there are two possible designs, inertial confinement and magnetic confinement, and it can be hoped if not confidently predicted that both can be made to work, and that we will be able to choose the better of the two.

Just recently there has been an increasing number of people, both technical and non-technical, asking if we can't just do another Manhattan Project, and simultaneously work our way out of the problems of global warming and soaring oil prices. Almost any large-scale scientific project can be accelerated by spending more money and placing more emphasis on it, but there is a limit. Brilliant innovators can make breakthroughs, but there still will always be the drip-drip-drip or whoosh-whoosh-whoosh of some slow process to play out. The technical term is the critical path. The worst aspects of the energy crisis are its global nature and the threat of catastrophe. Yet, in contrast to the Manhattan Project, we are not in a scientific race to win a wartime competition, but rather in a race to assist (if not save) everyone, and there is reason to feel that cooperation and collaboration are not only possible but essential. After such a project has succeeded, the National Labs and other participating governmental organizations can step aside, and let corporations or other entities operate fusion reactors or lasers, for profit or not, as is appropriate. The purpose of large-scale, big-budget science is not to compete with business, but to provide the necessary common backdrop of knowledge, understanding, prediction, and technology.

We have described a project, fusion research, that started out classified and competitive (for thermonuclear weapons), and has grown unclassified and cooperative (for electrical power generation), and in both of which the Lab plays a significant role. We have expressed the hope that the enduring contribution of the Lab will be to the peaceful use.

But the Lab has another role, a dual role, a darker role. 9-11. Terrorism. Fanaticism.

Defense of the nation, within which Homeland Security is but one component, is always going to rely on classified efforts, which in turn are always going to rely on up-to-date science. Perhaps the most terrible of all dualities is that science provides people with power, and power can either be used for destruction or to prevent destruction. Each new scientific discovery either contains a threat or threatens to contain a threat, and contains a promise or promises to contain a promise.

Return to the Manhattan Project once again. The Manhattan Project was essentially two projects: U235 and Pu239. A curious duality became apparent. It was relatively hard to produce U235, but relatively easy to design a bomb. It was relatively easy to produce Pu239, but hard as hell to make a bomb. With regard to the latter, enter a savior in the shape of John von Neumann, whose bust sits on the ground floor of the LLNL building that houses Blue Gene/L, not for the bomb, but for the computer. Consider what the world would be like if one of the U235/Pu239 possibilities were reversed, say that it was easy to separate U235 from uranium ore, and still easy to make a bomb, and hard to produce plutonium, and still hard to make a bomb. Iran would have the bomb. Switch the roles of uranium and plutonium, and North Korea would have the bomb. Let science sufficiently facilitate all sides here, and criminal gangs and fundamentalist terrorists can have the bomb.

Biology already has turned this hypothetical nightmare into a possibility. Biology is screaming ahead and can't be stopped, because, if nothing else, it promises to ease some people's suffering and to stop some people from dying. Right now politicians and members of the defense and intelligence communities are in serious arguments about which countries have the capability of making nuclear weapons, or are acquiring the capability. The ultimate fear of people who work on biodefense is that the corresponding question will become whose garage contains the equipment to make a terrifying weapon. Maybe even your looney neighbor's.

Research on biowarfare defenses is necessarily sited at a secure Lab, since some of the research and development must be classified. In addition, some "wet" research must be done on dangerous pathogens or potential pathogens, and the Lab has as much expertise in the handling and control of dangerous substances as can be found anywhere, along with hardened buildings, a formidable Protection Force, perimeter defenses, Gatling guns, surveillance devices, and other accessories.

On the other hand, arguments exist both for and against non-defense-related biological research at secure Labs. It is instructive to examine some of them.

An argument against is that, given the Lab's security overhead costs, it would be inefficient to fund at the Lab biological research which is already being conducted elsewhere in private industry or academia. There has been a huge investment in corporate genomics research for a multiplicity of non-defense applications, mostly but not entirely medical, and in academic research for the usual purpose of bringing light into darkness, with the possible serendipitous side-effect of a few patents to bring sunshine to endowment managers. However, an interesting historical illustration of the value of combining government-sponsored and private-sponsored research is given by the sequencing of the human genome. Actually, "combining" might be the wrong word to describe what was more of a competitive collision. We can see in the history of genomics research abundant examples of both competition and collaboration, another duality of importance to this discussion.

One argument in favor of siting at least some significant non-defense genomics research at the National Labs is to support a quality biological research staff whose primary mission is biowarfare defense. The best way to maintain awareness of a rapidly advancing science like biology is to have cutting-edge research on site, along with regular presentations of results. Defense-related research cannot be intellectually isolated, and interaction and even open collaboration with other researchers, both onsite and offsite, is imperative. One advantage to an onsite capability is that basic research can be steered to the needs of the defense applications, as the need arises.

Conversely, the Labs amortize some of their research costs by sharing discoveries and technologies, when possible, with other government agencies (e.g., CDC), academic Labs (LBNL), research consortiums (Joint Genomics Institute), corporate researchers (Applied Biosystems), and business interests (farmers faced with a crop or livestock biothreat).

We see here an example of the value of preserving the integrity of different types of organizations to pursue their goals, even if there is some added cost due to duplication of effort. Overlaps can provide an incentive to compete, or a link to collaboration.

The duality between Lab resources that are maintained and nurtured on site, versus outside contractors or imported resources, creates an environment where you usually see plenty of both, with continually shifting boundaries. It is not only difficult but counter-productive to try to circumscribe the scope of most large-scale scientific endeavors, and almost impossible to accurately predict what resources will be required.

It isn't just terrorism we need to defend against -- there is always going to be the possibility that science will enable some new threat to be used against us. Perhaps against all of us. This requires the government to be sited at or near the cutting edge of science, and also requires that a classified scientific capability be sited at a secure Lab.

Different organizations have different basic values, different goals, different methods, and different operational environments. To conflate these conceptually is to lose sight of the distinctions and risk diminishing some of the values. To subsume them all under one is to undermine the values of the others.

Dualities are persistently manifested both in comparisons of organizations of different types, and in studies of the essential characteristics of organizations of a single type. We will use these dualities repeatedly to delineate the differences between the National Labs and other types of organizations, to uncover some essential characteristics of the Labs, and to illustrate the basic theme of this paper, which is that the essential identity and integrity of the National Labs should be preserved. In no way will an argument be made that the National Labs should subsume other types of organizations; this would be an error dual to the one we oppose.

We begin by describing a stark duality between corporations and universities regarding research. We will find the National Labs in a straddle.

The primary purpose of corporations is return on investor capital. This doesn't mean that corporations don't contribute to some greater good. Adam Smith is optimistically cited as having shown that the contribution to the greater good follows in an optimal way from the pursuit of optimal investor returns, and this is sometimes true. When corporations do research, it is generally to advance their competitive advantage. The results of such research are usually protected by patent or held in confidence as proprietary intellectual property, subject to non-disclosure agreements. This paradigm has been weakened recently by assorted computer companies that are sharing their research advances as never before, seeing greater rewards down the line. Nevertheless, the contrast with academia is still stark.

Academics generally disseminate the results of their researches as quickly as possible. They even jump the publication gun and send out preprints to colleagues all over the world, to establish priority rights. Preprints prevent unnecessary duplication of effort, and protect the latest addition to the author's collected claims (or pretensions) to historical immortality. They also make it difficult for governments or corporations to insert dams into knowledge streams.

Los Alamos National Lab (LANL), with one of its numerous technological innovations, brought this process into the computer network age with arXiv.org, an e-Print Archive, presently operated by Cornell University, now containing about 500,000 e-Prints in Physics, Mathematics, Computer Science, Quantitative Biology and Statistics. These are unrefereed papers, posted by the author(s), and time-dated to establish priority. Changes and revisions require new and separate postings, to maintain sharp benchmark times. Other fields have, or are developing, similar electronic archives. This development has made academic advances in the fields mentioned almost manditorily available both instantaneously and universally.

The National Labs present a curious hybrid, created by the duality between classified research for national security purposes and scientific research for internationally shared benefits. Disseminating the results of classified research earns you the hostility of a powerful government, and a brief spot in the limelight before you disappear into a dark hole. On the other hand, with few exceptions, the Lab not only has no interest in retaining scientific results whose release would have no negative impact on national security, the Lab has every reason to release such results for the common national, if not global, good. Add a press release, and the public can be reassured that their tax dollars are going to more than just nuclear weapons, and that the Lab also does good things for good people for good reasons.

The taxpayers pay most of the Lab's bills, and the Lab has developed ways of sharing knowledge, expertise, and resources with both academia and business. The Institute for Scientific Computing Research, to which the author belongs, serves primarily for liason with faculty and students. Summer student visitors do an amazing amount of interesting research, and allow Lab staff scientists to share the benefits and pleasures of teaching that are enjoyed by professors. Some students later become Lab employees, and some of them allow staff scientists to share with professors the benefits and pleasures of being out-performed by their students.

The Industrial Partnerships and Commercialization program allows companies to contract to share Lab scientific expertise, which often has been developed for other purposes with Lab resources that cannot be duplicated elsewhere because of costs. IPAC also has programs, subsidized in part by DOE, to spread awareness of new Lab scientific and technical developments, so that duplication of effort is avoided, and companies are made aware of opportunities to collaborate with the Lab.

Often one project at the Lab will utilize the knowledge and resources of another division, department, or project. NIF, which has infrequent but valuable tours for Lab employees, provided an example during a recent tour. One of the NIF scientists tasked to answer questions lauded the value to NIF of the help of materials scientists at the Lab, who came through with some vital solutions to pressing problems. On a large-scale project with both classified and unclassified applications, the balance between onsite and offsite technical support tends to shift in favor of onsite. However, in some cases a collaboration is necessary not only between onsite and offsite resources, but between totally different types of organizations. The design and construction of Blue Gene/L was a collaboration between LLNL and IBM, with great benefits to both sides.

Before we turn to a description of how the Lab works, we pause to consider if something useful can be derived from an emphasis on dualities, besides perpetually providing German philosophers and physicists with something to write about. There are those who see a duality and think antithesis, competition, and even hostility. A tension develops, and seeks resolution through one side, well, doing the other side in, if not just swallowing the other side whole. Others see an antithesis but desire a synthesis that will be more progressive and lots better than the two sides individually. Some would prefer to keep the two sides separate, and have them either cooperating, or competing, or doing both, or switching back and forth, as appropriate. If the two sides are to compete, there is always the nagging problem that occurs when one side starts winning all the time. If they are to cooperate, there is always the chance that they might just decide to, well, merge, and even begin to conspire against others.

Those who are unable to accept the complexities of numberless hordes of dualities, with shifting modes of competition and collaboration, will not appreciate the essential nature of the Lab, and can pose a threat to the effective existence of the Lab. Just the idea of designing and building high-quality nuclear weapons in the hope of preventing everything from coming apart before we can figure out some way of getting rid of them, all of them, is difficult for most people. But even here, some adherents of the two sides have turned from what used to be hostile and violent protest clashes to a more civilized but still effective exchange of hopes and methods. Every Good Friday courteous protestors line the west side of the Lab, and most respect the formidable security perimeters. Those who wish to penetrate are allowed to do so only in order to reach chairs, tables, coffee, and donuts, where they can comfortably await transport to jail. The one thing both sides have in common is a serious and active concern about an issue of real and over-riding importance. Mostly they have learned to respect each other.

A greater threat is posed by those who wish to upset delicate Lab balances between security and openness, between classified and unclassified, between military and peaceful, between deterrents and destroyers, between big and little explosions, between theory and applications, between scientists and non-scientists, between government and business, between government and academia, between academia and business, between on site and off site, between job security and layoffs, between specialization and versatility, between mandated and chosen, and so ad infinitum. For over sixty years, the Lab has developed methods and situational characteristics that are designed to deal with these issues, and those methods and the environment they create are derivative of its nature. We now examine some of these truly unique aspects.

It is quite common, for example, to find someone who got a PhD in physics, went on to become a specialist in some branch of computing, and now specializes in climate modeling or biology. This versatility, the ability to redefine oneself professionally, is almost unknown in academia, where specialization is the rule. In most (but not all) corporations, such field switching or straddling would be likely to arouse suspicions. Hetero-specialization is more of a side-effect than a main goal of the Lab, although recognition of its value has certainly grown.

The Lab offers a certain type of job security that is similar, but not equivalent, to tenure in academia, or the lifetime employment commitment found in many Japanese firms. It is not to the Lab's benefit to have people with classified information in their heads moving in and out of Lab employment. It is, for example, easier to keep track of people who know vital nuclear weapons secrets if they are on site. It is also true that employment at the Lab carries with it some liabilities for future employment sought elsewhere; if nothing else, your Lab specialty may not be of much use to anyone on the outside (excluding those who certainly should not have it anyway). Furthermore, not every corporation or academic institution is enthusiastic about the work done at the Lab and the people who do it. Within the Lab, the need for people with different specialties varies with time, and often depends on the most recent state of a dangerous world. People cannot be just yo-yoed in and out; some resources must be kept available and provided with interim duties during low-demand periods, whenever possible.

An interim job classification is Employee Between Assignments (EBA). If the project you are on gets cancelled, or just runs out, and you have not been able to preposition yourself for a next one, the Lab gives you a period of time, with pay, to search out another position at the Lab. The Lab is a large place, with disparate projects, and one can keep busy for some time searching for an opening. Since the Lab does not want the EBA clock to run out, it maximizes the opportunities for those EBAs who have been longest in the job search, rather than lose them, which adds to the average EBA time period, but preserves the basic intent.

The Lab sponsors and manages Lab Directed Research and Development (LDRD), locally conceived, defined, proposed, generated, executed, and evaluated, paid for by a "tax" on outside project budgets. This provides a transitory opportunity for a scientist to do what he/she really hankers after, and possibly to make a scientific contribution whose possibility could only have been recognized through other Lab-based research and development.

Finally, the Lab offers generous retirement benefits. The motivation here is apparent from the preceding; the Lab wishes to keep its employees through to retirement, and then to provide generously for their service.

In simple terms, the Lab does everything it can to keep its people. And the Lab fosters a spirit of teamwork and patriotic contribution to the defense and welfare of the nation that cannot be created otherwise. Some people might be doing better pay-wise at the Lab than they could on the outside, but many also accept less. All accept a working environment that, to an outsider, would appear Orwellian. Sign here, and throw away your privacy. (Some newcomers feel that they are also being asked to put their soul in escrow.) However, the Lab is not a social club or an enterprise; it is primarily a national nuclear security laboratory. Security restrictions are imperative.

The management of the Labs has recently undergone a Transition. LANL, LLNL, and (obviously) LBNL have been managed by the University of California from the start, until recently. The historical reasons include the fact that both Oppenheimer and Lawrence taught at UC Berkeley. The Los Alamos of the Manhattan Project was considered to be an extension of the University of California. Although U235 and Pu239 were the essential ingredients in the construction of the atomic bomb, the ingredient that necessarily preceded them was a trainload of professors. The precedent for academic management was established, but there is no way to overestimate the unease created.

A sizable number of academics, if not a majority, feel that their university should not participate directly in nuclear weapons research, let alone operate a National Nuclear Security Lab. The usual value, to both faculty and the rest of humanity, is to have university research almost instantly available universally, as described above. How is this compatible with Q Clearance for a professor? If members of both the government agency that currently "owns" the Lab and the university that manages it have misgivings, what is the alternative? What are the reasons for making a change?

The new management team is called Lawrence Livermore National Security, LLC (LLNS), whose members are the University of California, Bechtel National, BWX Technologies (BWXT), and Washington Group International. Battelle is a "Teaming Subcontractor", along with several other smaller businesses, and Texas A&M University is an "Academic Teaming Subcontractor". The change from management by the University of California to management by this consortium is called "the Transition". The U.S. Department of Energy (DOE) and the National Nuclear Security Administration (NNSA) selected LLNS to manage and operate Lawrence Livermore National Laboratory. The contract began Oct. 1, 2007.

The University of California is the world's largest academic research institution, and Bechtel is the largest project management contractor in the United States. BWX Technologies and Washington Group International are the top two DOE nuclear facilities contractors and between them manage and operate four of DOE's five sites. Battelle commercializes technology, performs contract research and manages laboratories for government and industry. Texas A&M University provides a second academic alliance. Before Robert Gates became Secretary of Defense, he was president of Texas A&M. Said it was the best job he ever had.

It can easily be argued that corporate managers are more professional, knowledgeable, and competent than, for example, academic administrators (e.g., deans). A lot of the administration of the Lab is done by scientists (or, sadly, former scientists) and technical people, rather than the more specialized and efficient managers found in competitive corporations. Ask anyone at the Lab if the Lab is run with maximum efficiency, and they are likely to scoff, burst out laughing, or even shy away with fear that you might be dangerous.

On the other hand, if you ask about the quality of the directors of specific units, you will often find respect, praise, and even awe at the capabilities of individuals who are not only outstanding scientists, with the ability to stand toe-to-toe and eye-to-eye with the scientists and technicians they manage, but effective and savvy managers and decision makers. There are remarkable individuals who not only have these dual talents, but have the ability to excel in both roles simultaneously. J. Robert Oppenheimer is the premier historical example (although the author has talked to old hands at Los Alamos who would be bundling their old hands into fists right now). Most academics can hopefully point to some dean or department chairman who was both at or near the top of his field and a blessing to work under.

The purpose of this discussion is not so much to solve the question of effective management as to address the questions of what the Lab's essential values are, who should own the Lab, and how to get the benefits of efficient management without sacrificing the Lab's basic values.

It is difficult to see how a lot of past scientific progress would have been possible under corporate management. How, for instance, could corporate managers have decided to underwrite research intended to determine whether or not "elementary particles", like the electron and proton, were actually composite? We now presume that the first is not, and know with scientific "certainty" that the second is, and have the field of quantum chromodynamics to model the quark-gluon composition of the latter. Such discoveries will always be made by researchers who have been given an opportunity to push through the veil that obscures some scientific unknown (later a squadron of scientist vultures will begin circling), and not by managers who have already managed to guess what lies behind the veil.

History is largely influenced and even steered by basic scientific revelations, basic not because of their simplicity or transparency, but because of their foundational importance. As Oppenheimer put it, everyone else harvests the fruit. The Manhattan Project, with its physicists, was not the only Wartime example; the code-breaking efforts at Bletchley Park in England were led by Alan Turing, a mathematician, who created much of the modern theory of computation, and who managed to supervise the construction of some at-the-time awesome computers to break the German Enigma Cipher.

More recently, an algorithm specialist at the Center for Applied Scientific Computing used a well-tested metaphor by saying his group was riding on the shoulders of mathematicians. One mathematician responded good-naturedly that it felt more like riding on their backs.

No corporate executive or government bureaucrat wants to, as one DHS administrator recently said, "buy junk", but the risks obviously rise in the presence of, to quote Rumsfeld, the "unknown unknowns" of scientific research. Government is better equipped to average the costs of such failures against the proven rewards of participation in the successful discoveries. No government can ever know or predict exactly what future challenges will require a massive scientific response, and history is not kind to those who abandon their defenses, intelligence capabilities, and commitment to share (if not to exclusively occupy) the scientific lead.

It makes little sense to "privatize" the Lab, as some have suggested, and even more perplexing is the oft-quoted suggestion that the National Nuclear Security Labs should be run at a profit. The author is reminded of a faux pas he committed the first time he met Stanislaw Ulam, at Los Alamos. Knowing that Ulam, Teller, and Everett shared top billing on the patent for the hydrogen bomb, he asked Ulam if he would get royalties if the bomb were ever used. Ulam replied that he had not found the question tasteful or amusing the first time he heard it, some decades and many instances earlier.

General Motors might be pleased that they help people get around in automobiles, yet be seriously concerned about their bottom line. The Department of Defense might be pleased with the cost-effectiveness of some weapon, but seriously concerned with the results to the nation of its deployment or use. The emphasis varies with the goal. Any organization whose benefits mostly acrue neither to the people who own it nor to the people who operate it exists for some other good than profit. What does it mean for a National Nuclear Security Lab to be run at a profit? Or the Central Intelligence Agency? The Centers for Disease Control? The National Science Foundation? The University of California? None of these organizations should waste money, but, if they are to be run at a profit, what is being sold at more than cost, and for whom are the profits intended?

This following is completely anecdotal, but the author was recently moved by a comment from a friend from the National Security Agency, a man who is so far to the right wing that his bird in flight requires constant correction to prevent clockwise roll. He said that he appreciated the contributions made by the contractors who had proliferated throughout the Agency, but that he thought a sense of mission, a spirit of "can do", and a feeling of belonging to a common team had somewhat been lost.

One can study or criticise the Transition by addressing the why, the how, and the results. A "Transition" means a change from one thing to another, and before the change is complete, one can only predict the results. Give the managers of the Transition at least some credit for an ability to respond to developments, and the resulting uncertainties make predictions necessarily tentative if not sloppy. Uncertainty in, uncertainty out.

As to the why, the basic reason has to be improved management, and presumably at reduced costs.

However, since the quality of management at a National Nuclear Security Lab is going to be heavily weighted with measures of safety and security, it is possible that the leadership of Congress deliberately chose to factor in increased management costs for better quality. If so, the extra money seems to be missing. The Transition has caused a huge increase in management costs. Some of this is due to management fees that the University of California probably never even fantasized about. Some of it is due to increased upper-level salaries, sometimes by many multiples. Some of it is due to the Lab's loss of tax exemption. The Lab has not seen fit to share the numbers with the author, and isn't likely to, and the author is not going to seek them, and will not accept the numbers if offered, so that ends this paragraph.

Some economies have been achieved with an increase in security and only minor, and arguable, inconvenience to employees. For example, if you want your wastebasket emptied, you leave it in the hall, and now no one enters your office for this purpose. Increased operating efficiency, however, is not going to be adequate to compensate for increased management costs.

Since the Lab's budget was not adjusted upward, about two thousand employees have been laid off so far. This wholesale assault on job security emperils the whole concept of retaining people whenever possible, of EBAs, of versatile people redefining themselves, and of the "esprit de corps" that seems to disappear when people begin to compete for their own benefits rather than with a "can do" attitude toward common missions. Even if you were not "perp-walked" off the Lab with little notice (an exercise that is manditory for security at a nuclear security lab, but is also common in industry), it is rather a disappointment to see fellow employees who did a good if not superb job lose that job, especially when it is not clear why they are no longer needed. The Transition managers might even have done a credible job of selecting the right people to let go, given various built-in constraints regarding Lab employment, but that is rather a nuanced consideration given the overall effect. It is also difficult to explain why so few upper-level managers were laid off, when those that remain have so many fewer lower-level people to manage.

Add to this a lengthy and raging debate among Lab employees about whether or not the new pension plan is worse than the old University of California system, and morale is rather low. One wag offered the possibility that an announcement would be made that flogging would continue until morale improved.

The worst outcome of all of this would be that the essential nature of the Lab is lost, its values and goals and methods and environment. It was what it was because it worked. Maybe not perfectly, but it worked. Another real threat is that good people who were spared in the layoffs will leave. That is already happening. One employee, planning a new career elsewhere, described the Lab as in a downward spiral. To return to the metaphor used with good-natured humor on the author's NSA friend, it is not so much that the Lab is overloaded to the right and rolling clockwise, as that it might be pitched downward.

The real effect of the Transition will be in how well it works when it has settled into some new and relatively stable state, and not in the commentaries flying all over the place. Certainly not in this paper, which is more of an attempt to describe the factors involved. The Lab will have to redefine itself as the emphasis on nuclear weapons development and maintenance declines. There are numerous reasons to believe that the need for a secure and safe Lab devoted to big-budget scientific research and classified smaller-budget research will persist indefinitely. There is a lot of expertise of different types represented in the new management. If they can work together to preserve what the Lab is and does, that expertise can be summed. If the different values, goals, and outlooks of the participants clash, and competition or even confict develops, there will be subtraction.

The Manhattan Project is how it all got started, and still provides guidance. The next time the nation or even the world confronts a huge crisis, it would be useful not to have to recreate such a resource ex nihilo, but rather be able to focus an existing set of resources onto the problem.

There are times to compete and times to cooperate, and probably the most optimistic hope that we can have right now is that humanity will cooperate for once, almost if not perfectly globally, to confront and solve some serious existing common problems. And maybe someday someone will write a paper in defense of the International Labs and really-big-budget science.

To summarize, the world is populated by all sorts of organizations: business, academic, governmental, non-governmental, non-profit, religious, scientific, political, charitable, and so on. They have, by definition, different values, goals, methods, and environments. To retain the contribution to the general good of each, they should not be conceptually conflated, or lumped together on the ground. Those who advocate privatizing everything have no more wisdom and are (perhaps) no less dangerous than those who want to nationalize everything. The National Laboratories of the United States were brought into existence in what one can hope will be the biggest crisis humanity ever faces. They provide values, goals, methods, and environments that cannot be found elsewhere, that provide value to the nation and the world every day, and that should not have to be created again from scratch if we suddenly find that we need such resources in the future or have failed to appreciate what we had.

To tinker with their given nature is like asking your wife to get a nose job. Even if the results are satisfactory, the long-term consequences for the relationship are almost certain to be negative.

Corrections, comments, or criticisms are welcomed.

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