4-9385(1)

UCRL-ID-115182

Industrial Grand Challenges — A Competitiveness Strategy for the DOE National Laboratories

Roger W. Werne

October 14, 1993

This is an informal report intended primarily for internal or limited external distribution. The opinions and conclusions stated are those of the author and may or may not be those of the Laboratory.

Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

**This report has been reproduced
directly from the best available copy.**

**Available to DOE and DOE contractors from the
Office of Scientific and Technical Information
P.O. Box 62, Oak Ridge, TN 37831
Prices available from (615) 576-8401, FTS 626-8401**

**Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.,
Springfield, VA 22161**

**Industrial Grand Challenges —
A Competitiveness Strategy for the DOE National Laboratories**

**Roger W. Werne
Associate Director for Engineering and Technology Transfer
Lawrence Livermore National Laboratory**

Introduction

The Cold War has been won; won in part by superior technology; superior technology such as that found in the DOE national laboratories. However, new challenges face the country, for it is clear that our historic notions of national security have changed to include economic security as well as defense. Economic security means that our industries are able to successfully compete in international markets in order to provide a high domestic standard of living. It is also recognized that U.S. industries must achieve and maintain a leadership in technology and that the technology base of the DOE national laboratories must now be mobilized to support U.S. industry. Once again the laboratories are called upon to support the country in a time of need.

Because of this need we are seeing a significant change in mission for the Department of Energy national laboratories in their role as problem solvers for the nation. In particular, the Defense Programs (DP) national labs (Lawrence Livermore, Los Alamos, Sandia National Laboratories, and Martin Marietta Energy Systems Y-12) are moving from closed institutions to open centers with significant resources ready to support U.S. industry more vigorously than ever before. The DP laboratories are enthusiastic about their new mission and are reaching out to industry in an effort to understand industry's needs and find applications for Laboratory skills and technologies. From these discussions with industry, it is clear that there is no consensus on how best to work together, however, some important points emerge and are worth noting:

- They want our help but are frequently unsure of the mechanisms.
- They want access to knowledge, equipment, and facilities they do not have.

- They want to reduce the risks of long-term, high-risk R&D.
- They want long-term relationships.
- They are unsure of the Labs' dedication and responsiveness.
- They are concerned about government inflexibility and intrusion.

Similarly when talking about "technology transfer" with commercial research labs such as Battelle Columbus, SRI International, Southwest Research Institute, Carnegie Mellon Research Institute, the Fraunhofer Institutes in Germany, and others who have supported the private sector, they also make some important points:

- Organizations not having their own research labs tend to be their biggest customers.
- Small- and medium-size companies seem to reap the most benefits.
- Long-term relationships are important—"must get to know and trust each other."
- Technology transfer occurs—"shoulder-to-shoulder" over time.
- Companies needing help the most can afford it the least.
- Large central research labs may see you as a competitor.
- Flexibility is essential since no two deals are alike.
- You must respond on a time scale that is relevant to industry's needs.

The challenge facing the DP labs is, therefore, to find mechanisms both legal and cultural that will enable them to utilize their considerable technical resources to improve U.S. economic competitiveness on the global scale.

Strategy

When thinking about economic competitiveness and a strategy for how the national laboratories can support U.S. industry in their global competition, it is useful to think of technology transfer as occurring at three levels:

Level I is spin-off technology that is developed in the normal course of programmatic accomplishment. In terms of its impact on industry, it falls into the category of product and process improvements. The important point is that the commercial value is serendipitous rather than by design because this type of technology was developed for uses other than the commercial market.

Level II is cooperative research and development in which joint industry-Laboratory teams work on a problem that neither could solve separately, with the objective of applying the results to the commercial market and to Laboratory needs. This kind of R&D is usually incremental in nature, provides market pull for Laboratory technologies, and utilizes the intellectual resources of both industry and the Laboratory to mutual benefit.

Level III is breakthrough R&D that creates a new market or paradigm shift in an existing market. These projects are higher risk and longer term than those at Level II, but also have much higher potential payoff. It should be noted that national laboratories like Livermore, Los Alamos, Sandia, and Y-12 were originally chartered to search for the breakthroughs and paradigm shifts in weapons technology. We now need to take that creative problem-solving skill and turn it toward the commercial sector.

The long-term contribution of the national labs to economic competitiveness lies in their ability to solve breakthrough problems that will make a difference, i.e., to be the high leverage problem solvers for the Nation. Industry should answer the following question: "What problems exist in your industry that if solved would make a major difference in your competitive position in the international marketplace?" These are the problems that the national laboratories should be tackling. We call these the "Industrial Grand Challenge Problems" because of their potential importance to both the private sector and government. There will be more discussion of these later.

Examples of the three levels of cooperative work Livermore is conducting with industry are shown in Table 1. The industries across the top are those, most economic leaders agree, in which the United States must be strong in order to be an economic superpower in this decade and beyond. And it is precisely the technologies forming the foundations of these industries where the national laboratories are world class.

The following are examples from each of the three levels of cooperation: In the area of spin-offs, our most successful example is a computer code called DYNA3D. At the time it was written in the late '70s and early '80s, it solved the problems of bending, folding and buckling of metal structures more accurately and faster than any other software in existence. It was developed at Livermore as part of our weapons research program. The automobile industry recognized its utility for crash simulation almost immediately and DYNA3D quickly became the world standard for crash simulation. Boeing is now using it to help design structures to contain failed turbine blades, while the Adolph Coors Co. brewery uses DYNA3D for more efficient manufacturing of aluminum cans. One of DYNA's most recent uses is by the biomedical community to look at the effects of impact trauma on the human body. Recently a study was performed by consultants from the University of California at Davis to assess the commercial impact of DYNA. They found that American industry annually saves about \$350 million from DYNA3D and its commercial derivatives by reducing costly product development tests, improving designs and shortening time to market. This is significant leverage for an original investment of about \$6 million.

The second level of support to American industry is cooperative R&D in which our intellectual resources are combined with private industry's to jointly solve a problem that neither could do separately. An excellent example is superplastic steel, a special formulation featuring ultra-high carbon and fine grain structure. When this material is heated to about half of its melting point, it flows easily, thus giving good void-filling characteristics in forging dies. With it we believe we can make near net-shaped parts at low manufacturing cost. In pursuing superplastic steel we have assembled a vertically integrated R&D consortium. Livermore and Stanford University are doing the R&D. Northstar Steel is responsible for scaling the process from laboratory to industrial quantities. Ladish is the forging company; that is, they prescribe the rate of deformation and other parameters needed to economically produce parts. And Caterpillar Tractor is the end user. This consortium is particularly productive because each partner depends upon the success of the others for its own success, thus encouraging a significant degree of cooperation.

In the area of breakthrough technology, an outstanding example is soft X-ray projection lithography. Lithography is the process by which extremely thin lines of a metal conductor are applied on a silicon chip. By making the lines thinner, they can be packed more densely and the chip can be reduced in size; the resulting computer

performs faster. In the 1970s the United States controlled the lithography market, but lost it in the 1980s to the Japanese. Our goal is to help recapture the market in this decade by exploiting the soft x-ray optic technology developed at Livermore. Today we have about a five-year lead in this technology over Japan. Teams from Livermore and Sandia National Laboratory are working with a consortia consisting of companies like ATT, IBM and Intel, among others. Our goal is to create a paradigm shift in technology that would recapture the lithography market for the United States.

Recall the question to industry, "What problems exist in your industry that if solved would make a major difference in your competitive position in the international marketplace? Many industries have identified such breakthroughs, which I call the "industrial grand challenge problems." Here are some examples that have been presented to the national laboratories by industry, i.e., "Help us..."

- Take the automobile out of the environmental equation.
- Reduce NO_x & SO_x emissions by 90 percent (diesel and coal).
- Create a sub 0.1 micron lithography capability.
- Create the massively parallel computing algorithms that solve real problems such as crash simulations in 10 seconds rather than 10 hours.
- Increase cell sorting speed by a factor of >100.
- Replace radiographs by digital images for improved mammography.
- Develop key technologies for the high speed civil transport and the national information infrastructure.
- Develop minimally invasive microsurgical techniques that will significantly reduce patient recovery time and therefore cost.

and many more.

A natural question now arises: What are the characteristics of an industrial grand challenge problem? First, it is important to both the government and private sector, each for their own reasons. Second, it is so large, complex or expensive that industry cannot solve it alone. Third, its solution is necessary to carry out government policy. And

fourth, the solution will be implemented on a large scale through the private sector, thereby saving or creating jobs.

Several criteria can be used to select industrial grand challenge problems. One is that their solutions are necessary to implement government policy. An example might be to help industry meet statutory requirements. If the federal government passes a law that requires private industry to meet a requirement and the technology is not available, the government, through the national labs, can provide the R&D required to solve the problem. Examples include meeting environmental law, fuel efficiency standards and safety standards. Another example of helping to implement government policy is meeting national objectives, such as energy independence, national information infrastructure, global climate change, cost effective environmental remediation, and health care cost reduction.

A second criterion for industrial grand challenge problems is that problem solutions are important to the strategic position of U.S. industry in the global marketplace. Computers, advanced materials, satellites, communications, agriculture, energy technology, aircraft, pharmaceuticals and health care are all industries where the United States government has a long, unbroken record of R&D support during the past 40 to 50 years. These are also healthy and competitive industries in the international marketplace, and I submit that at least part of their success is due to government support for R&D that feeds the technology base of those industries. To maintain this health and improve the competitive position of others, the capabilities of the national laboratories must be made available to industry because they represent an important part of the domestic technological infrastructure, and advanced technology is the "seed corn" for future market success.

Implementation of the Grand Challenge Strategy

As mentioned earlier, the long-term value of the national labs in supporting U.S. competitiveness may be as a high-leverage, problem-solving resource to industry. A problem-solving resource that will enable industry to tackle some of the tough technological problems whose solutions would enable them to gain a significant advantage in the international market. However if left to their own capability, these companies may tend not to tackle these problems because the risk of failure is too high.

In short the national labs are "enablers" which can enhance the probability of success of a U.S. company or consortium of companies which decide to push the limit of their technology significantly beyond existing boundaries in order to gain an advantage in the international marketplace.

To take full advantage of the capabilities of the national labs and to support all levels of industry from small business through large corporations, all three levels of support as defined earlier must be done. For example it is reasonable to assume that a Lab like Livermore could work on four to eight Grand Challenge problems (Level III) simultaneously. In fact I could argue that Livermore is already doing that because of its programs in Inertial Confinement Fusion (ICF) which has the goal of harnessing fusion power, Atomic Vapor Laser Isotope Separation (AVLIS) for uranium fuel enrichment, the Human Genome project to understand how genetic information is passed from one generation to the next, and the Soft X-ray Projection Lithography project for the next generation of computer chips.

Cooperative research and development between Lab researchers and the private sector (Level II) using cost shared agreements is also very active with Livermore having over 80 such agreements with over 110 companies. On a steady basis, Livermore could probably do 100-200 such agreements with an average scope of \$1M and lasting one to three years each.

The transfer of spin-off technology (Level I) to the private sector occurs in many ways. Of course technical reports and publications are an important source of information but licensing of protected information to individual companies is essential if capital investment is required to bring a new technology to the market. A third form of spin-off which is available to companies of all sizes, but which is particularly important to small and medium size companies, is the transfer of know-how through direct consulting and problem-solving. LLNL is participating in a DOE-sponsored small business outreach program which will allow Laboratory scientists and engineers to help small companies with some limits on the scope of work to be performed. User facilities in which outside people can come in and avail themselves of unique Lab facilities and capabilities are also an important form of spin-off.

Overall, there are many ways in which a lab like Lawrence Livermore National Laboratory, or any other lab for that matter, can support U.S. industry in global

competition. As we learn more about industry and they about us, these mechanisms will need to evolve.

Conclusion

In conclusion, the DOE national laboratories must dedicate themselves to working on industrial grand challenge problems that can make a major difference to industry and the country. They've done it in defense, they can do it in the commercial sector if they work with industry to identify the industrial grand challenge problems and to jointly solve them. They must then work with government to prioritize the problems as to their value to the nation and develop programs around solving the highest priority problems.

LLNL contributes to competitiveness across a broad spectrum

	Advanced Materials	Telecomm	Aerospace Aircraft	Biotech	Software & Computers	Advanced Manuf.	Advanced Electronics	Energy
Spinoff	<ul style="list-style-type: none"> • Aerogels • Cermets 	<ul style="list-style-type: none"> • Antenna modeling 	<ul style="list-style-type: none"> • Tomography of turbine blades 	<ul style="list-style-type: none"> • Monoclonal antibodies • Contig Browser • Chromosome Painting 	<ul style="list-style-type: none"> • Mass storage • Systolic Processing 	<ul style="list-style-type: none"> • Precision machine tools • DYNA3D 	<ul style="list-style-type: none"> • 3D Electro-magnetic Modeling • Sensors 	<ul style="list-style-type: none"> • Geo-chemistry
Cooperative Development		<ul style="list-style-type: none"> • Gigabit switch • Opto-electronic modeling 	<ul style="list-style-type: none"> • Remote Imaging • Non-destructive evaluation 	<ul style="list-style-type: none"> • Enhanced mammography • High Speed Cell Sorter 	<ul style="list-style-type: none"> • Paradyn 	<ul style="list-style-type: none"> • Super-plasticity • Laser welding 	<ul style="list-style-type: none"> • Electronic packaging • Micro-Sensors • Gas Immersion Laser doping 	<ul style="list-style-type: none"> • Oil shale retorting
Paradigm Shift			<ul style="list-style-type: none"> • LEANSAT 	<ul style="list-style-type: none"> • Micro-Instruments • Accelerator Mass Spectrometry 	<ul style="list-style-type: none"> • Massively Parallel Computing 		<ul style="list-style-type: none"> • X-ray projection lithography 	<ul style="list-style-type: none"> • Laser Isotope Separation

END

**DATE
FILMED**

12/22/93