FINAL REPORT

April 1994

HPCC TECHNOLOGY AWARENESS PROGRAM

**“Improved Economic Competitiveness Through Technology Awareness,
Transfer and Application”**

**DoE Grant
DE-FG03-93-ER25149/A000**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, 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 product, 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 any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**IG TECHNOLOGIES
5090 Shoreham Place, Suite 109
San Diego, California 92122
619-558-9283**

Study Contributors

Dr. Randolph A. Graves, Jr.

Dr. Carl G. Murphy

Dr. Kathleen P. Sridhar

Mr. Roger L. Webb

This report was prepared under a Department of Energy (DoE) Grant DE-FG03-93-ER25149/A000. The principal value of the Grant was \$50,016. The principal objective of the study was to assist DoE in enhancing the ability of DoE's National Laboratories to transfer High Performance Computing and Communications (HPCC) Program technology to U.S. Industry.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ABSTRACT

HPCC Technology Awareness

A need has been defined by Congress for the DoE National Laboratories to participate in various dual use and technology transfer programs. This requirement has spawned several technology transfer approaches at the DoE laboratories. These programs are designed to encourage large and small business to bring their problems and needs forward, and to allow the labs to transfer effective high performance computing technology to the commercial marketplace. This IG Technologies grant from the DoE was undertaken to address the issues and problems associated with technology transfer between the DoE National Laboratories and commercial industry. The key focus is to gain an understanding of how DoE and industry independently and collectively view the requirements and the missing elements that could allow DoE to facilitate HPCC technology transfer.

At issue is HPCC Technology Transfer for the High Performance Computing industry and its relationship to the DoE National Laboratories. Several observations on this are addressed. The issue of a "Technology Utilization Gap" between the National Laboratories and Independent Software Vendors is discussed. This study addressed the HPCC Technology Transfer plans of all six DoE National Labs. Study team members briefed numerous industrial users of HPCC technology as to the feasibility of technology transfer for various applications. Significant findings of the effort are that the resistance to technology transfer is much higher than anticipated for both the National Labs and industry. Also, HPCC Technology Transfer is observed to be a large company's dominion. Small businesses have a difficult time in addressing the requirements of technology transfer using Cooperative Research and Development Agreements (CRADA's). Large businesses and the DoE National Labs however, often have requirements and objectives which are at cross purposes, making effective technology transfer difficult.

The HPCC focus on Massively Parallel Processing is widening the technology transfer gap between DoE and industry. No effective software model exists that will support the adoption of high risk MPP technologies into the mainstream of commercial computing. The concept of an Application Conversion Foundry (ACF) which would be an organization developed by DoE to facilitate the technology transfer process between the National Laboratories and commercial users is discussed.

Key Words: High Performance Computing and Communications (HPCC), Phases of Software Development, Technology Translation, CRADA, Massively Parallel Processing (MPP), Technology Transfer Gap, Application Conversion Foundry (ACF), Technology Transfer.

This Page Left Intentionally Blank

EXECUTIVE SUMMARY

A study was conducted for the Department of Energy to assess the available High Performance Computing and Communications (HPCC) technologies residing at DoE's National Laboratories, to catalog available technologies (and capabilities) and to prepare/present a Technology Awareness briefing of the Labs' technologies/capabilities to a cross section of U.S. industry. The National Laboratories' capabilities and available technologies were compiled and forged into a briefing that was presented to a cross section of U.S. companies. The feedback from the briefings formed the base for some significant findings that lead to a recommendation for resolving the HPCC technology transfer gap.

Significant Findings

- **The DoE National Laboratories Have Outstanding HPCC R&D Capabilities**
- **The HPCC Technology Transfer Gap is Much Wider Than Anticipated**
- **The HPCC Focus on MPP is Further Widening the Technology Transfer GAP**

Conclusions

- The National Labs are a clear national asset with a proven track record in high performance computing R&D. Significantly changing the Labs roles and missions to add technology transfer may only serve to diminish their collective capabilities. DoE should not weaken the strength of the Labs by significantly changing their mission, but instead *provide an intermediary whose sole mission is to accomplish the required technology maturation and transfer to industry.*
- The technology transfer gap is bigger than anticipated as a result of a combination of factors, the principal ones being: the immaturity of the HPCC technology, the risks of adopting radically new and unsupported technology, the perception of the Labs being competitors to U.S. companies and the cumbersome CRADA process.
- U.S. Industry relies heavily on software that it has developed or purchased with an emphasis on minimizing the development costs, risks and ongoing maintenance/support. This means that industry depends on the infrastructure of standard, universally accepted programming paradigms and tools for building mission critical software. The HPCC Program focus on Massively Parallel Processing (MPP) results in the development of radically new software approaches which have little supporting infrastructure and very high risks. The resulting proliferation of immature/risky MPP technologies is widening the technology transfer gap.

Recommendation

Establish the ***HPCC Application Conversion Foundry*** to provide a simple and effective interface between the national Laboratories and the High Performance Computing community. The ACF would enable the translation and transfer of appropriate HPCC technologies to meet the needs of independent software vendors, industrial firms and governmental organizations. This single point of contact considerably enhances the National Laboratories' commercial technology mission by providing an effective means for the risk reduction required before technology can be adopted by industry. The risk reduction comes through the translation of the technology to meet end user requirements and the thorough verification/validation (maturation) before transfer.

The ACF would also provide supporting activities that are not in the normal mission of software R&D organizations: documentation, training, support, maintenance, upgrades, technology prototyping and user requirements analysis.

This Page Left Intentionally Blank

TABLE OF CONTENTS

1.0	Background Information	1
1.1	Introduction	1
1.2	Technology Utilization Gap	1
1.3	Technology Transfer: The Keys	2
1.4	Objectives of Grant	3
1.5	Grant Deliverables	4
2.0	Grant Activities	4
2.1	Data Gathering	4
2.1.1	Laboratories Contacted	4
2.1.2	Laboratory Responses	4
2.1.3	Compilation of Capabilities	4
2.1.4	HPCC Related CRADAs	4
2.1.5	Test Visit	5
2.2	Technology Awareness Briefings	5
2.2.1	Preparation and Presentation	5
2.2.2	Feedback on Industry Needs	5
2.3	Observations from Briefings	6
2.3.1	Feedback	6
2.3.2	Observations	7
2.4	Observations on Industrial Technical Computing	7
2.5	Conflicting HPCC Laboratory Roles and Missions	9
3.0	Significant Findings	10
3.1	DoE National Laboratories Outstanding Capabilities	10
3.2	HPCC Transfer Gap Much Wider Than Anticipated	10
3.3	MPP Focus Widening Technology Transfer Gap	10
4.0	Conclusions	10
5.0	Recommendation	11
5.1	Application Conversion Foundry	12

Appendices

- A. Phases of Software Development
- B. Technology Translation
- C. Laboratories Capabilities Briefing
- D. Sample DoE CRADA
- E. Facilitator Approach to CRADA Success

This Page Left Intentionally Blank

1. BACKGROUND INFORMATION

1.1 INTRODUCTION

High-performance computing has long been recognized as a powerful tool, with pervasive use in such diverse areas as industrial design and manufacturing, scientific research, communications and information management. There is a widespread perception among government and academic leaders that high-performance computing plays a pivotal role in the technological performance of the United States. Within high-performance computing, advances in numerical simulation of engineering systems are responsible for many improvements in design, development and manufacturing processes. Numerical simulation is now considered the third major branch of scientific solution, taking its place alongside theoretical methods and experimentation. Numerical simulation is not separate from the other two; rather it is a combination of theory and experiment into a powerful new device that can provide rapid, accurate insight into physical reality.

Insight gained via modern numerical simulation techniques offers an opportunity to break the traditional "Edisonian" build-and-break development cycle. Numerical simulation reduces the resource-intensive fabrication and test phases to a single computer simulation phase. This rapid and low-cost parametric testing of the product by numerical simulation offers such distinct advantages as reduced development and manufacturing costs, reduced development time (faster product-to-market time), the ability to tailor products to specific markets, and improved product quality and reliability. These attributes can be the basis for improved U.S. technological competitiveness, pointing up the importance of the continued development of advanced numerical simulation tools.

If numerical simulation is to provide the path to improved competitiveness via its advanced design and development tools, then the simulation software must meet certain criteria pertaining to usability, applicability and reliability. Further, the simulation must offer rapid evaluation of the design so that changes can be incorporated earlier, and it must reduce the overall costs of the design and development process. This means that the simulation and related software must move effectively from the world of R&D where it is conceived (i.e. National Laboratories) to the realm of engineering application where it is used.

1.2 TECHNOLOGY UTILIZATION GAP

Historically, the movement of technology from R&D to industrial application was slow but effective. Industry was the driving force behind most research efforts and did most of the funding, with R&D responding directly to industrial and commercial needs. This was the so-called "technology pull" environment, with industry pulling needed technology from the R&D sector. However, the vast technological advances required by the U.S. defense and space programs in the 1950s and 1960s established a trend toward federal funding of technology research and development, a practice that continues today. R&D efforts now drive the technology development process, supported by continuous federal funding. This is a "technology push" environment, where the R&D sector develops technology and attempts to push it into commercial use. The end product of a given R&D effort is not necessarily technology that is in a usable form for industrial or commercial application.

This has set the stage for the unfortunate fact that the recent prodigious production of new technology in general, and of simulation software in particular, has not always been followed by its use in the commercial arena. Though the technology is there in abundance the commercial and industrial communities have lagged behind the R&D community's pace in accepting and using it, creating an ever-widening gap between technology development and technology utilization.

This gap is very apparent in the world of advanced applications software, where the outstanding R&D

efforts of the National Laboratories and the academic community have produced remarkable advances in the pioneering application of numerical simulation to complex physical phenomena. The R&D communities have produced myriad research and pilot computer codes that have seen varying degrees of use and validation. These pioneering applications often lack such industrial requirements as user-friendliness, smooth interfaces with input/output devices, or validation over a large range of application. The industrial community is reluctant to be early adopters of advanced software applications. This has led to a growing gap that increasingly isolates the industrial and commercial communities from a wealth of new technology that could be tapped for competitive gains.

The above figure is taken from a National Academy of Sciences study (see Reference A-1) which looked at the development process for applications software development in Computational Fluid Dynamics. This is a five step process that can be generalized into three distinct development phases: R&D, Transition and Production. Appendix A gives a detailed description of each of these phases. The gap between available technology and utilized technology occurs at the transition phase, the point where verification and validation enables the software technology to move from proof of concept to useful code. Within the traditional R&D missions of the National Labs, there was little emphasis on moving from the R&D phase to the production phase. After all, the transition phase requires a different skill mix and management techniques that are not part of the traditional R&D culture.

Further, the R&D and industrial communities are "culturally" isolated from each other, widening the gap still more. In the world of industrial design there is a well established infrastructure of support, including college curricula in design, an extensive literature base, and industry conferences and symposia. Likewise, the R&D community has its own similar but separate infrastructure of support. The two communities advance separately, in a parallel fashion, and their diverging cultures, rewards, peer pressures, literature, and conferences serve to exacerbate the technology utilization gap. There is no well established infrastructure for the validation phase, and the lack of a clearly identified community hinders support for effective software technology transfer. While this is a problem, it can be viewed as an opportunity for the DoE and the HPC program to create an effective infrastructure for software transfer.

1.3 TECHNOLOGY TRANSFER: THE KEYS

Of what then should a successful technology transfer process consist? It should certainly begin with an awareness on the part of industrial and commercial users as to what technology is available, leading to the

identification of some pertinent candidate for eventual use. The chosen technology must then be translated into a form that meets industrial requirements, and finally it should be implemented by the user. These steps, their function, and routes to successfully accomplishing each must be explored.

a) Technology Awareness

The first step to successful technology transfer, the awareness of technology availability, leads to the effective and efficient identification by industry of needed new technology. This first step of awareness is the key to the transfer process; without open and timely access to many technology sources, potential users of new technologies will continue to pursue "business as usual," their inertia carrying them down time-worn paths. For the end user in the industrial community the search for new technology is a daunting process, with many sources at multiple locations to be canvassed. An open and timely process for promoting technology awareness, then, must necessarily be an active one. This approach would educate potential users on the availability of new technology.

b) Technology Translation

The next step in the transfer process involves the translation of the identified technology into the appropriate form to meet such end-user requirements as applicability, usability and reliability. This resource-intensive phase contains the traditional validation activity of verification and testing of the technology over the entire range of intended use. And herein lies the classical gap between developers and users: each thinks it is the other's responsibility to validate the technology. Designers won't risk using a code that's not completely tested nor easily usable, and researchers won't spend their time putting all the "bells and whistles" on a code that's already quite technically sound. Because of the lack of financial incentive to each community, the overlap between them, where cooperative joint technology translation and validation should occur, is missing. See Appendix B for additional detail on technology translation.

c) Technology Implementation

The final step in the transfer process is the implementation of the technology by the end user. Given a successful technology translation effort, implementation requires little additional effort if the legal/administrative/bureaucratic forces are held at bay. The danger lies in the current practice of implementation of technology that has not been properly translated, resulting in discouraged industrial designers and abandonment of the technology, i.e., the technology utilization gap.

1.4 OBJECTIVES OF GRANT DE-FG03-93-ER25149/A000

The purpose of the Grant to IG Technologies is lay the foundation for the initiating the Department of Energy National Technology Awareness Program to enhance the transfer and utilization of new HPCC technologies emerging from the National Laboratories' research programs. Specific objectives of the effort are to:

- Assess the available HPCC technologies resident at the participating National Laboratories
- Catalog new (available) technologies
- Compile available technology and skills for industrial presentation
- Prepare and present industrial Technology Awareness briefings

1.5 GRANT DELIVERABLES

- a) Technology Outreach Briefing
- b) Final report
- c) Industrial needs

2.0 GRANT ACTIVITIES

2.1 DATA GATHERING

2.1.1 Laboratories Contacted: The list of DoE Laboratories participating in the High Performance Computing and Communications program was provided to IG Technologies by DoE Headquarters along with the principal Laboratory HPCC contacts. IG Technologies forwarded a letter (and FAX) to each of the participants requesting their active support in gathering the background information required for the Grant. The following Laboratories (and HPCC principals) were contacted:

Argonne National Laboratory	Tom Morgan
DoE Headquarters	Gary Johnson
Lawrence Livermore National Laboratory	Hank Shay
Los Alamos National Laboratory	David Cartwright
Oak Ridge National Laboratory	Ken Kliewer
Sandia National Laboratories	Sudip Dosangh

2.1.2 Laboratory Responses: The responses by the Laboratories varied considerably both in rapidity and quality of response. The rapidity of response was directly proportional to the Laboratories' prepared HPCC materials. Those with well planned programs in technology transfer provided quick response with high quality information in readily usable form. The Los Alamos National Laboratory was the best prepared, providing detailed information on the full range of its HPCC activities; and its principal HPCC contact, David Cartwright, was very knowledgeable and always responsive. All of the principal contacts could speak authoritatively on their HPCC programs and on technology transfer in general, however, their follow-up and ability to deliver varied widely. The least prepared and least responsive of the Laboratories was Sandia. However, all requisite Sandia information did finally arrive, albeit not in readily usable form. This data gathering process was IG Technologies' first indication of the variations in preparedness and levels of interest in technology transfer by the individual Laboratories.

2.1.3 Compilation of Laboratory HPCC Capabilities/Technologies: In Appendix C, the resulting compilation of the individual Laboratories' capabilities, technologies and interests are tabulated by Laboratory. This compilation formed the basis for the initial technology awareness briefings given to industry representatives. The compiled results are most impressive and represent a considerable national research capability covering almost every aspect of high performance computing. The HPCC Program coordination between the Laboratories appears well managed, with little existing overlap or redundancy.

2.1.4 HPCC Related CRADA's: IG Technologies obtained from DoE the list of CRADAs in effect as of May 1993 and compiled from the master list (Appendix C) those CRADAs related to high performance computing. In all, there were 50 computing related CRADAs with 23 in software. It was immediately apparent that the majority of the CRADAs were with large companies with almost no small business representation. By reading the abstracts of the individual CRADAs, it was also apparent that many of them were with the R&D departments of large companies and not with product development or product marketing organizations. After reviewing the DoE sample CRADA document (Appendix D), IG

Technologies' principal investigators realized that what was beginning to emerge from the data gathering process was a technology transfer process that could only be afforded by large companies with well funded R&D departments. This trend was counter to the traditional product innovation and introduction by small companies that has been the driver of much of the progress in the technology sector of the U.S. economy. As part of the Grant effort a briefing on the needs and problems of small business was prepared and presented to DoE Headquarters and laboratory personnel. See Appendix E for the briefing.

2.1.5 Test Visit: Two IG Technologies representatives were sent by Mosaic Multisoft Corp., a start-up software developer for multiprocessing, to Sandia National Laboratories in Albuquerque, New Mexico to investigate the possibility of obtaining new technologies for commercialization. The timing of the trip was driven by two separate needs: first, Mosaic Multisoft had an immediate need for C++ programming tools and libraries and secondly, IG Technologies wanted first hand knowledge of the initial stage of technology transfer. This trip took place well before all of the Laboratories' capabilities, technology and interests had been received and compiled, thus allowing for incorporation of trip results into developing the technology awareness briefings. The immediate result of the visit was disappointing for Mosaic Multisoft Corp., but it did provide IG Technologies valuable insight into the issues and problems surrounding the transfer of technology from the DoE HPCC R&D activities. The Sandia personnel had little understanding of the level of maturity required for industrial use, much less for commercial productization. The unreal expectations of laboratory personnel that businesses, particularly small businesses, would assume all of the risks in commercialization of software technology without some form of (limited) exclusivity was particularly frustrating.

2.2 TECHNOLOGY AWARENESS BRIEFINGS

2.2.1 Preparation and Presentation: The core briefing, Appendix C, was compiled, prepared and trial-briefed, at Lockheed's Information Technology Company, before final charts were prepared. This core briefing formed the basis for several shorter versions that were prepared and presented to industry groups and special forums. A wide range of companies were briefed or supplied with the briefing package. IG Technologies also arranged for attendance and presentations at two RCI, Ltd. symposia to encourage active technology awareness of DoE Laboratories' capabilities and technologies by organizations utilizing High Performance Computing. IG Technologies' personnel gave technology awareness briefings at RCI, Ltd. meetings in Boulder, Colorado and Knoxville, Tennessee based on the core briefing developed under this Grant. Special presentations were given at the Washington DC meeting in November 1993 to RCI's Aerospace and Chemical/Pharmaceutical Special Interest Groups which were well attended by a cross section of America's industry.

The following is a list of companies/organizations that were briefed using the briefing package:

DuPont, Monsanto, IBM, Grumman Data Systems, High Performance Technologies Inc., MRJ Inc., TriAda, Scientific Computing Associates, GTE Government Systems, Lockheed Information Technology Company, California Small Business Development Center, Adaptive Solutions Inc., Martin Simpson & Company, Mosaic Multisoft Corp., Maui Research and Technology Center, IWG Corp., CTA Inc., Drantz Inc., Westinghouse Electric Corp., Intel Corp., plus others at the RCI symposia.

The briefings, personal contacts and formal presentations results were that the initial level of interest in the presentations and DoE's technologies was high however; this interest waned rapidly. A follow-up letter failed to attract further involvement from those contacts. IG Technologies did make contact with a number of organizations that had initially shown interest and found that the desire for involvement became much less enthusiastic as the level of management increased.

2.2.2 Feedback on Industry needs: From the series of presentations given, personal contacts made and informal group discussions, IG Technologies personnel compiled the following list of industry high performance computing needs:

Programmability

- "Standard" Parallel Programming Model
- Software Portability
- Software Scalability
- Improved Programming Tools
- Code Conversion Tools
- Improved Distributed Computing Environments

Scientific/Engineering Codes

- Serial/Vector/Parallel Versions
- Distributed/Clustered Workstation Versions
- Less Emphasis on MPP

Infrastructure Needs

- High Capacity/Speed Mass Storage
- Multilevel Network Security

Trustworthiness

- Reliability
- Robustness
- Documentation
- Support
- Maintainability/Upgradeability

Applications

- Faster Turnaround
- Improved Accuracy
- Faster Pre/Post Processing
- Portability

Technology Transfer Needs

- Low Cost/Low Risk Access
- Software Protection (Licensing)
- Ongoing Software Maintenance/Support

2.3 OBSERVATIONS FROM TECHNOLOGY AWARENESS BRIEFINGS

2.3.1 Feedback: IG Technologies personnel became aware of a consistent set of issues, perceptions and observations during the briefing process that focused on the CRADA as a vehicle for transfer, the readiness of Laboratories' technology and the Laboratories' understanding of and interest in technology transfer. Some of the important perceptions were:

- Industry is not generally aware of (a) the technology available from the National Labs nor (b) the steps toward getting a CRADA to transfer a particular technology to industrial use once it has been identified.
- CRADAs have a reputation for being difficult and take too much time to process in spite of having templates available and Laboratory "support."
- CRADAs place all risk on the industrial partner and none on the individual Laboratory.
- CRADAs can require too much payback for technology that is too immature and unproven.
- The Laboratories have no interest in getting mature (verified, validated and documented) products into the marketplace.
- The Laboratories do not follow well established industrially required quality software development procedures.
- Laboratory personnel naively believe that software is market ready at the end of its R&D phase.
- The Laboratories promote a "can-do-anything" attitude about high performance computing that is not credible.
- Unsupportable Laboratory positions and claims about parallel/multiprocessing hardware capabilities are taken as proof that the Laboratories have no concept that software and software costs are the major consideration in industrial adoption of new parallel/multi processing technologies.
- The Laboratories have a very strong bias towards research computers instead of widely used production quality systems, resulting in the Laboratories being perceived as prejudiced and not as independent sources of reliable computing information.

- The Laboratories compete with independent software vendors by creating and distributing free software developed with taxpayers money. (See front page article in Washington Technology, March 24, 1994 entitled "Beating Swords into Profit Motives: Industry is Irlked at Some Aggressive New Competitors - - The DoE Labs.")
- The Laboratories are unwilling to grant exclusive licenses to new technologies.

2.3.2 Observations: The above perceptions may or may not reflect reality, however the perceptions are prevalent and freely voiced. A major part of the problem is that the roles and mission of the Laboratories has changed quite visibly and the Labs lack a coherent business concept that is consistent and credible. Until the Labs have such a business plan (model), it is unfair to require them to make undefined contributions to national competitiveness by operating in their traditional research role as well as their new role of product development. The HPCC Program has left the Labs with a reputation as being advocates of narrow niche projects instead of impartial technology evaluators. As a result, they are perceived as competitors rather than partners in high performance computing technologies.

The dearth of a coordinated DoE business strategy (plan) across the Labs has led to an overall lack of focus and has provided an environment where representatives from different Laboratories often speak in contradictory terms. Many Laboratory representatives often talk about involvement in research only, while others talk about partnering with business for product development and others see technology transfer as a cash flow device based on royalty fees. This inconsistency is confusing to the business community and is not the environment that fosters effective technology transfer.

2.4 OBSERVATIONS ON INDUSTRIAL TECHNICAL COMPUTING

IG Technologies observed many areas of high performance computing (HPC) where a notable technology utilization gap exists between the research and industrial communities. The area of parallel/multi computing is an important example of this gap and the attendant need for a cooperative technology transfer process.

With the speed of single processors approaching its limit, the computer industry has moved to parallel/multiprocessing as a way to improve the overall processing speed on today's complex application software packages. Many vendors have introduced multiprocessing systems, which span the range from desktop to supercomputers.

At the high end of multiprocessing are the scalable parallel systems, where the HPCC Program has made great strides. Indeed, HPCC research programs and their ARPA predecessors have successfully shown that such scalable systems are feasible up to teraops level. The MPP computers take their place alongside vector supercomputers as a valuable tool to meet the vast computational needs of many ultra-sized research problems and of certain leading edge applications in industry. However, the MPP machines are programmed by mapping/message passing, a difficult, programmer-intensive approach that permits ultraperformance on only select applications and only on the hardware for which they are written. In addition, software for the MPP machines is inadequately supported, lacking such features as software maintenance and upgrades, user support and user documentation. The HPCC program created a Massively Parallel Processor (MPP) industry that would not have existed without the influence and active support of the Federal Government. National Lab practices have resulted in the advocacy of particular MPP architectures and programming concepts, but the lack of effective programming models and tools for MPP machines has seriously restrained the adoption of HPCC supported MPP into the mainstream of commercial computing.

If MPP computers have not gained wide commercial acceptance, what is the current role of parallel computing in industry? This must be answered by examining the needs of commercial production in general, and which of those have been met by parallel/multi computing.

Industrial production relies increasingly on numerical simulation in all phases of the production process, from analysis to design, development and manufacturing. These processes typically involve software development in one of two ways: integration of independent software vendors' (ISVs) existing products or development of proprietary software products. The integration route to industrial software development consists of tying together software packages from ISVs for use in industrial productization. Software costs and risk are thereby minimized, and reliability is maximized. Firms that choose to develop proprietary software products incur significantly higher software investment costs and often build their businesses around the proprietary software. For example, LSI Logic has developed proprietary electronic design automation software that accepts customers' electronic designs generated by ISV packages (e.g., Mentor, Cadence). The proprietary software does the detailed time verification and the manufacturing specification required for productization.

Whether production computing involves ISV software integration or proprietary software development, it still depends on an infrastructure of standard, universally accepted tools for building products: compilers, debuggers, operating systems, network communications and the like. Further, production computing relies on widely available, proven and accepted hardware platforms of all sizes. These include personal computers, workstations and mainframes, and for some large organizations, supercomputers.

Vector supercomputers, a type of parallel computer typified by the Cray line and high end Convex machines, have been embraced by some companies for competitive reasons. For example, Auguron, a San Diego firm that designs drugs to fit the biophysics of the disease, has taken the risk of moving to vector supercomputers because their competitive advantage is in reaching a solution faster than others. They explore, keep abreast of and experiment with parallel computing entirely for competitive reasons. The vector supercomputer alternative is an extremely expensive and non-portable one, suited only to certain types of problems. Both on a cost and performance basis, Auguron would certainly benefit from a more general-purpose, large parallel platform. However, small firms such as Auguron cannot move to large parallel platforms until the way is clear to easily port and maintain their software there. They cannot be expected to make such a move until a common set of tools and operations are available across a wide range of large parallel platforms.

Some companies have added small symmetric multiprocessors to their computing facilities, enabling them to do throughput multiprocessing (one complete job on each processor) while still using the standard operating systems and tools. Sequent, Pyramid and Encore, for example, provide symmetric multiprocessors to the database server market and are successful because of their software programming approach and adherence to standard programming tools. The programmability afforded by small processor counts, symmetric multiprocessing architectures and by widely used Unix operating systems has fostered the rapid growth of workstation-based symmetric multiprocessor servers by Sun, IBM, Hewlett Packard, Silicon Graphics, and DEC, to name only a few. Once again, the software programming approach is the key to the success of these symmetric multiprocessors.

The next stage of development in the commercial sector is for parallel machines that perform all the functions of mainframes, but at higher speeds. Market entries from companies like IBM, CRAY Research and Kendall Square, for example, use technologies and approaches growing out of MPP research and development, but with a distinctive bias toward software programmability. The result is that the commercial parallel processing market has grown by providing solutions based on software, not on raw hardware processing speeds. *The commercial parallel computing marketplace is driven by software, not by hardware.*

For the most part, however, besides the small forays into symmetric multiprocessing and vector supercomputers, most production-focused companies have not added such "exotic" platforms as large parallel computers to their facilities. These systems lack effective programming models, and few tools and techniques exist to allow for commercial production programming across a wide range of parallel platforms. Further, large parallel platform reliability is poor; this coupled with difficult programmability

makes large parallel platforms a high risk choice for software developers across the board.

Industrial production computing users do not make radical moves. They (wisely) wait for platforms to be proven and require a smooth transition from present methods to new ones before they will make changes. This means that parallel platforms of interest in production computing are those for which software can be easily ported and can run effectively and reliably. These industrial parallel computing needs are in direct contrast to the characteristics of the MPP architectures advocated by the National Labs: extremely hard to program, non-portable software, low hardware and software reliability, and inadequate software support. The Labs' efforts to transfer the MPP technology to industry users will continue to fail because the technology does not meet industry needs. If HPCC technology transfer to industry is an important goal, the Labs must look to industrial needs and focus its vast resources on meeting them.

2.5 CONFLICTING HPCC LABORATORY ROLES AND MISSIONS

Historically, developing and advocating technology that was transferrable to industry was not part of the mandate of the National Laboratories. The difficulty of dealing with communism loomed over the nation, and meeting the challenges of the Cold War drove the U.S. computing mission to outstanding achievements. The Labs' mission-driven computing past must be recognized as a unique time when their leadership in supercomputing was government supported at high cost and effort. But with the fall of communism the focus shifted; the void in defense related programs was filled via the Technology Reinvestment Program (TRP) and the Dual Use Program, among others. Such Lab missions as computer design of advanced weapons systems were replaced with new government-declared national needs like weather prediction and modelling the human genome. These new computing needs, the so called HPCC Grand Challenges, are an attempt to perpetuate the Labs' old mission-driven model of operation, but with a demanding new goal of conducting the research while contributing to industrially transferrable technology.

It is not at all clear, however, that maintaining the Labs' old roles, structures, cultures and traditional research approaches will result in fast and effective transfer of technology to industry. A time scale of a decade or more for government sponsored research to filter down to use in the marketplace is not uncommon. Indeed, to use the parallel/multicomputing example again, *the Labs' MPP thrust over the last ten years amounts to business as usual, with the industrial technology transfer role only as an add-on.* The National Labs have advocated the ideal computers for their research needs and have supported them through application building, aiding particular vendors where necessary to achieve the desired results. This mode of operation was essential to accomplishing the Labs' mission when the required technology was not available in the marketplace. The MPP architecture or software produced works well for the Labs' needs, but not for the computing community as a whole. The general beneficial impact on industry comes indirectly and over an extended period of time. In all fairness, direct short-term technology transfer has often proven difficult, even between research and production departments within a single company. Even so, making a direct and short term transfer of HPCC technology to industry is a burden for which the Labs are historically, structurally and culturally ill prepared.

By being advocates of particular MPP architectures, as was appropriate in earlier times, the National Laboratories have lessened their capability for working with the computer industry. Their advocacy has made them competitors to commercial organizations instead of partners. This nearsightedness has led them to misunderstand the computational needs of industry, hiding the requirements for methods and tools that apply across a wide range of algorithms and architectures. The National Laboratories cannot make a positive impact on industry as long as they are perceived competitors and blind advocates of industrially unacceptable architectures.

U.S. competitive needs require that the *marketplace* make effective decisions and not be unduly influenced by the R&D community's choosing of winners. If the Labs' mission is to be permanently extended to aid industry in solving its computational problems, the focus of HPCC should change to

reflect industrial needs. The general needs, requirements and limitations of HPCC should be broadly explored at the National Labs, and HPCC programs should be evaluated in terms of potential positive industrial impact. Planned research efforts that are generally applicable to a wide range of potential future computer architectures and software programming approaches would result in technology that is transferrable to industry. Laboratory research advances that apply across the board will significantly impact the future of high performance computing and allow the true potential of the HPCC Program to be realized.

3.0 SIGNIFICANT FINDINGS

3.1 DoE National Laboratories Have Outstanding HPCC R&D Capabilities - The traditional R&D mission of the Labs has provided DoE and the U.S. research community with premier high performance computing capabilities. The historic role of high performance computing in the development of advanced weapon systems has produced a wellspring of technological advances and an unprecedented pool of talent. One only has to look at the breadth and depth of HPCC capabilities cataloged in Appendix C to understand the capabilities and expertise available at the DoE National Labs. While the new roles and missions of the Labs may not be clear, there is no mistaking the strength of the Labs. The Labs are a clear national R&D asset and any significant change to their traditional role will only serve to diminish the collective capabilities.

3.2 The HPCC Technology Transfer Gap is Much Wider Than Anticipated - With the outstanding capabilities available at the National Labs, IG Technologies personnel in the initial stages of the Grant assumed that the outstanding HPCC technologies/capabilities would be attractive to U.S. industry and provide an incentive for technology transfer. This was not the case; IG Technologies personnel found that there was considerable reluctance to engage in the technology transfer process with the National Labs. The key factors were the immaturity of the HPCC technology, the significant risks of adopting immature, radically new and/or unsupported technology, the perception of the Labs being competitors and a cumbersome CRADA process (and especially expensive for small businesses).

3.3 HPCC Focus on MPP is Widening the Technology Transfer Gap - There is an increasing reliance on numerical simulation in industry in all phases of production. These numerical simulations rely on software that depends on the infrastructure of universally accepted tools and standards. The use of standard approaches in software development minimizes risks, thereby maximizing reliability. The HPCC program has focused almost exclusively on MPP with strong advocacy and support from the National Labs, resulting in non-standard specialized programming models and tools. This lack of effective programming models (widely accepted software development procedures) and programming tools has seriously restrained the adoption of HPCC supported MPP into the mainstream of commercial computing. *The HPCC focus on a narrow area of high performance computing is producing radically different and immature computing technology that is widening the technology transfer gap.*

4.0 CONCLUSIONS

U.S. Industry relies heavily on software that has been developed as proprietary software or integrated from standard independent software vendor (ISV) packages. In either case, the emphasis is on minimizing development costs, risks and ongoing maintenance/support. This means that industry depends on the infrastructure of standard, universally accepted programming paradigms and tools for building mission critical software. This infrastructure includes standard languages, compilers, debuggers, operating systems, communications, and widely available, proven and accepted hardware platforms. Industry is moving rapidly into multiprocessing at the low end through the use of multiprocessing workstations and servers that provide a stable (low risk) approach to higher performance computing. Outside of a few isolated, specialized uses of MPP in transaction processing, there is no discernible trend to industrial adoption of MPP for production computing.

The National Labs are a clear national asset with a proven track record in high performance computing R&D. Significantly changing the Labs roles and mission to add technology transfer may only serve to diminish their collective capabilities. The efforts required to verify, validate and document HPCC technologies for commercial use is not a traditional role the Labs performed, nor one they are sufficiently well equipped to do. The historical success of the Labs is due to their strong R&D culture, structure, facilities, experience and motivation. DoE should not weaken the strength of the Labs by significantly changing their roles or mission, but instead *provide an intermediary whose sole mission is to accomplish the required technology maturation for transfer to industry.*

The CRADA process for technology transfer is cumbersome, can be very time consuming and is perceived to transfer the risks for new technology onto industry. It is significant that many of the existing CRADAs are between the R&D departments of very large corporations and the National Labs. While DoE and the individual Labs have instituted programs to assist the business community from small to large firms, the CRADA process is viewed as a vehicle only large companies can afford. This process needs to be replaced by standard business practices of licensing, leasing or purchasing commercial grade software. This can only be accomplished by establishing a central organization whose mission is to provide effective technology transfer in an efficient business manner on behalf of all of DoE's Labs.

5.0 RECOMMENDATION

Establish the ***HPCC Application Conversion Foundry*** to allow the HPCC Program to embrace independent software vendors, industrial organizations and governmental agencies. The objective of the Application Conversion Foundry (ACF) would be to significantly narrow the HPCC technology transfer gap by enabling the translation (Appendix B) and transfer of appropriate software technologies to meet end user needs. The ACF would provide an effective, efficient and uniform interface to the business world for all of DoE's HPCC organizations.

The ACF would be created and funded to provide the HPCC interface between the the DoE Labs and all other organizations. The ACF should not be part of the current Labs' organizations, but an engineering organization with the autonomy to freely conduct technology translation, transfer, support and maintenance. This autonomy assures that the end users' needs are met in a timely, cost-effective manner. The ACF will require a different and broader set of skills than are present in the National Labs. The key difference is a proactive, business oriented marketing program to provide constant interaction with the industrial community.

The ACF would provide true translation (conversion and/or re-engineering) of applications codes and not just porting to different computer architectures. The present technology transfer gap is largely due to the current technology residing at the National Labs not being in the appropriate form for transfer to industrial implementation. It is essential that the user needs be assessed and that enabling technologies be re-engineered to the appropriate form for near term contribution to U.S. competitiveness. For example, this may mean that new algorithms, solution techniques, software packages, etc. developed for massively parallel implementation would be translated into the appropriate form and validated for clustered workstations or networked heterogeneous computers. Many times the R&D developers of new technology do not recognize the wider implications of their activities; it requires the interaction of qualified technical marketeers with industry to correctly identify potential usage.

Section 5.1 below provides an overview of the ACF as envisioned by IG Technologies. The ACF model is recommended for further study and more detailed definition. The figure below is a conceptual overview of the ACF, providing a view of the operational interface functionality.

5.1 Application Conversion Foundry

Motivation: *Provide Effective HPCC Technology Transfer Interface for U.S. Industry*

Objective: *Enable Transfer of Appropriate Software Technology to Meet End User Needs*

Model: *Fully Functional Software Engineering Service Organization*

- *Specifications and Requirements Analysis*
- *Technology Assessment, Selection and Prototyping*
- *Technology Translation (Re-engineering/Conversion)*
- *Documentation/Training*
- *Support/Maintenance*
- *Upgrades/Improvements*
- *Technology Transfer (Sales, Leasing, Licensing, etc.)*
- *Industrial Joint Ventures*

Target Technology: *High Performance Computing*

Funding: *DoE Core Support Supplemented by Software Technology Transfer Fees*

- Benefits:**
- *Provides Simple/Effective Interface to User Community*
 - *Increases Likelihood of Transfer and Utilization of HPCC Technologies*
 - *Accelerates Usage of Advanced Computing Technologies*
 - *Provides Focus on HPCC Software*
 - *Eliminates Competition Between National Labs and Industry*
 - *Increases National Labs Awareness of Industrial Software Needs*
 - *Increases Industrial Awareness of DoE Capabilities*

- *Greatly Enhances the National Labs Commercial Technology Mission*
- *Provides Interactive Forum for Discussion of Future Trends and Needs*
- *Does Not Dilute the Strength of Either Industry or the Labs (in performing technology transfer tasks for which they are unsuited)*

This Page Left Intentionally Blank

APPENDIX A

Phases of Software Development

This Page Left Intentionally Blank

If numerical simulation is to provide the path to improved competitiveness through the provision of advanced design and development tools from the National Labs' broad base of research applications, then the simulation software must meet certain industrial use criteria. The questions that must be asked by potential users are:

1. Does the simulation increase the confidence in the design by giving accurate information on the design's performance throughout the intended envelope of use?
2. Is the information more complete than can be obtained by other means, assuring that no potentially catastrophic failure modes are overlooked in the design?
3. Will the simulation offer earlier and more rapid evaluation of the design so that required changes can be incorporated at minimal costs?
4. Will the simulation reduce the overall costs of the design and development process?
5. Has the simulation been adequately validated for the intended range of use?

Of the questions on this list, questions 1 and 5 get directly to the heart of numerical simulation: *does the simulation give accurate results and can they be trusted.*

The production use of engineering applications software requires mature codes that can be used and trusted in the design and development environment by unsophisticated users. Whether the codes are general purpose or specially customized design tools, they must meet certain use criteria that can be generalized into three categories: Applicability, Reliability and Usability. These three terms are the heart of the requirements specification for end use.

Applicability

The simulation increases the confidence in the design by providing accurate information on the design's performance throughout the intended envelope of use

The information is more complete than can be obtained by other means, assuring that no potentially catastrophic failure modes are overlooked in the design

Reliability

The simulation software has been adequately validated for the intended range of design use

Usability

The simulation software offers earlier and more rapid evaluation of the design so that changes can be incorporated at minimal costs.

The simulation reduces the overall costs of the design and development process

The software development process has been well stated in Reference A-1.

Phase I: In this phase the enabling technology is produced and consists of algorithmic research with little or no useful code realized. However, the concepts for future research codes are hypothesized. This phase is the realm of the scientist, with much of the work occurring in Universities and Research laboratories. Most of the funding for this phase comes from the Federal Government: NSF, DOE, NASA, etc.

Phase II: Here limited pioneering application codes are developed and the first rudimentary physical simulations are attempted. This is the phase where the initial comparisons with observational truth (experiments) are conducted. The scientists and engineers applying these codes are often provided with surprises resulting from program "bugs" and conceptual errors. Much of the work in this phase is conducted in Federal Research Laboratories and Universities.

Needless to say, the first two phases in the development cycle produce little in the way of useful production code. The culture, rewards and goals of the developers at this stage are very different from those of the end users.

R&D Phases		
Characteristics	Phase I	Phase II
Level	Enabling Technologies	Technology Demonstration
Products	Concepts/Algorithms Scientific Papers	Pioneering Applications Research Codes Technical Publications
Developers	Scientists/Researchers	Scientists/Researchers Engineers
Location	Universities Research Foundations Laboratories	Universities Computational Institutes Laboratories

The highly trained and skilled developers are more likely to be interested in pushing the leading edge of research which will bring them prestige and peer recognition. From the computational standpoint, they are interested in the algorithms, architecture, speed, memory, etc. The research codes developed at this point require expert users and are very limited in application. At this stage in the development process, risk is very high. The principal output at this point is scientific papers and conference presentations.

Phase III: Usefulness begins to emerge and the validation process begins in earnest. The application code undergoes a transformation from a narrow

research development to a more general purpose code with a wider envelope of usefulness. This phase is the transition phase with a wide overlap of participants. This is the traditional demarcation between the Research Laboratories and Universities and the industrial developers/users. While the potential usefulness emerges, there yet remains a significant level of risk. This is the entry point for many industrial users and many have in-house groups to take the application software from here through the advanced design tool stage. The critical maturation activity at this point is the validation of the application software.

While there is wide overlap in the makeup of the developers in the transition stage, there is no "transition community" like there is for the R&D and Production Stages. This lack of a technically identifiable community contributes to the gap in the development process and hinders the transition of codes from R&D to Production. From this point on in the process the usefulness increases and the Research Lab and University involvement diminishes rapidly, for this is becoming the traditional realm of the industrial user.

Transition Phase	
Characteristics	Phase III
Level	Integration/Validation
Products	Useful Applications Pilot Codes Engineering Analyses
Developers	Researchers/Engineers
Location	Federal/Industrial Laboratories Software Companies

At this point, there may be some sacrificing of technical sophistication for wider applicability.

Phase IV: This is the phase where final validation of the application is made over the intended envelope of use. This is generally carried out in the industrial setting and often includes specialized experiments to provide the last detailed validation particularly near the principal point of use. This development is generally conducted by engineers or specially trained technicians who are close to the ultimate application. This phase often involves the design engineers as a learning experience. The usefulness increases rapidly and is accompanied by a corresponding

reduction in risk.

Phase V: This is the final phase which continues until the software is retired in favor of new capabilities. Here the level of risk has diminished and continues to do so as the successful application of the software to real design problems occurs. This is the desired phase from the industrial standpoint, for here the codes mature into advanced design tools. At this point, the codes can be applied by the design engineers or technicians without detailed knowledge of software itself.

Production Phases		
Characteristics	Phase IV	Phase V
Level	System Validation	Mature Capability
Products	Production Code Engineering Analyses Documentation/Training	Robust Production Code Design & Dev Analyses Product Engineering
Developers	Engineers/Programmers	Engineers/Technicians
Location	Industrial Laboratories Engineering Departments Engineering Consultants	Industrial Design Groups Engineering Departments Engineering Consultants

In the production phases the concerns and goals of the developers/users are quite different from those of the earlier phases. The users are more likely to be less trained and relatively unsophisticated in the understanding of the technical development of the application software but are skilled at its use and will be concerned about its applicability, reliability, usability, programmability, maintainability, etc.

The extensive U.S. computational research community has responded exceptionally well to the call for more computer modeling with a prodigious production of new ideas and technologies across the spectrum of scientific and engineering disciplines. However, these activities have been almost exclusively confined to Phases I to II with some overlap into Phase III. Thus the industrial user has faced somewhat of a dilemma with the make or buy decision limited by the amount of Phase IV and V software that fulfills the questions posed at the beginning of this section.

To more clearly see the phasing of the development process of the three stages: R&D, Transition and Production, the combined phasing from Reference A-1 is reproduced below. The industrial user is faced with a gap in the development process at the transition stage because there is no clearly defined community which matures the software. Bridging this gap requires building confidence in the software and assuring applicability, reliability and usability through the validation process.

Additional supporting information on the impact of numerical simulation on the industrial design and development process can be found in references A-2 and A-3.

References

- A-1 Current Capabilities and Future Directions in Computational Fluid Dynamics, National Research Council, National Academy Press, Washington, DC, 1986
- A-2 Graves Jr., R.A., "Software Validation: The Bridge from R&D to Industrial Application," AIAA Paper 92-0587, 30th Aerospace Sciences Meeting, January 1992, Reno, Nevada.
- A-3 Graves Jr., R.A., "Engineering Service Organizations: The Tool for Industrial Competitiveness," Management White Paper No. 5, RCI, Ltd., Minneapolis, April 1991.

This Page Left Intentionally Blank

APPENDIX B

Technology Translation

This Page Left Intentionally Blank

Introduction

Within high-performance computing, advances in numerical simulation of engineering systems are largely responsible for the rapid improvements to date in design, development and manufacturing processes. The rise of numerical simulation has been rapid and has reached the point of almost universal acceptance.

Insight gained via modern numerical simulation techniques offers an opportunity to break the traditional "Edisonian" build-and-break development cycle. This cycle consists of a design phase to fulfill problem requirements and specifications, a fabrication and prototype testing phase, and lastly, an analysis to determine if the initial requirements were met. Since few designs are perfect, the process is necessarily iterative, requiring multiple expensive and time-consuming fabrication/test phases. Numerical simulation reduces the resource-intensive fabrication and test phases to a single computer simulation phase. This rapid and low-cost parametric testing of the product by numerical simulation offers such distinct advantages as reduced development and manufacturing costs, reduced development time (faster product-to-market time), the ability to tailor products to specific markets, and improved product quality and reliability.

These attributes are the very basis for improved U.S. technological competitiveness, pointing up the importance of the continued development of advanced numerical simulation tools. Indeed, according to Reference B-1, "depending on the complexity of the problem and the magnitude of the effort expended, [simulation] models range from excellent to merely suggestive in their quality and usefulness. In all cases, improvement of computer modeling is one of the most promising avenues to improved technological performance by our nation." A commitment to competitiveness means a commitment to leadership in numerical simulation.

If numerical simulation is to provide the path to improved competitiveness via its advanced design and development tools, then the simulation software must meet certain criteria, see Appendix A, pertaining to usability, applicability and reliability. Further, the simulation must offer rapid evaluation of the design so that changes can be incorporated earlier, and it must reduce the overall costs of the design and development process. This means that the simulation and related software must move effectively from the world of R&D where it is conceived, to the realm of engineering application

where it is used.

Historically, the movement of technology from R&D to industrial application was slow but effective. Industry was the driving force behind most research efforts and did most of the funding, with R&D responding directly to industrial and commercial needs. This was the so-called "technology pull" environment, with industry pulling needed technology from the R&D sector. Naturally, the results of the R&D efforts were validated, reliable and usable in industrial application, else no further R&D funding could be expected from industry.

However, the vast technological advances required by the U.S. defense and space programs from the 1940's through the 1960's established a trend toward federal funding of technology research and development, a practice that continues today. R&D efforts now drive the technology development process, supported by generous federal funding estimated by Business Week Magazine to be \$75 billion in 1991 alone. This is a "technology push" environment, where the R&D sector develops technology and tries to push it into industrial and commercial use. The end product of a given R&D effort, then, is whatever was agreed upon by the parties involved in the funding, and is not necessarily technology that is in a usable form for industrial or commercial application.

Further, technology developed without direct industrial input does not necessarily mesh with existing and planned industrial engineering procedures, making technology introduction still more difficult.

Technology Development Stages

Despite recent prodigious production of new technology in general, and of simulation software in

particular, this has not always been followed by its use in the commercial arena. Though the technology is there in abundance the commercial and industrial communities have lagged behind the R&D community's pace in accepting and using it, creating the observed, ever-widening gap between technology development and technology utilization.

This gap is very apparent in the HPCC world of advanced applications software, where the outstanding R&D efforts of the National Laboratories and the academic community have produced remarkable advances in the pioneering application of numerical simulation to complex physical phenomena. The R&D communities have produced myriad research and pilot computer codes that have seen varying degrees of use and validation. These pioneering applications often lack such industrial requirements as user-friendliness, smooth interfaces with input/output devices, documentation and/or validation over a large range of applications. The industrial community is therefore reluctant to be early adopters of advanced software applications. This has led to the growing gap that increasingly isolates the industrial and commercial communities from a wealth of new technology that could be tapped for competitive gains.

Technology Gap

<i>R&D Community</i>	<i>Industrial Community</i>
Investment	Return
Science	Engineering
R&D	Results
Challenges	Applications
Elite	Users
Literature	Products

Further, the R&D and industrial design communities are "culturally" isolated from each other, widening the gap still more. This tends to be true even when there are researchers and designers within the same company. In the world of industrial design there is a well established infrastructure of support, including college curricula in design, an extensive literature base, and industry conferences and symposia. Likewise, the R&D

community has its own similar but separate infrastructure of support. The two communities advance separately, in a parallel fashion, and their diverging cultures, rewards, peer pressures, literature, and conferences serve to exacerbate the technology utilization gap.

Of what then should a successful technology transfer process consist? It should certainly begin with an awareness on the part of industrial and commercial users as to what technology is available, leading to the identification of some pertinent candidate for eventual use. The chosen technology must then be *translated* into a form that meets industrial requirements. Finally, it should be implemented by the user, with provisions made for continued support of the technology.

Technology Translation

The critical step in the transfer process, see Reference B-2, involves the translation of the identified technology into the appropriate form to meet such end-user requirements as applicability, usability and reliability. This resource-intensive phase contains the traditional validation activity of verification and testing of the technology over the entire range of intended use. And herein lies the classical gap between developers and users.

Technology Translation

Designers won't risk using a code that's not completely tested nor easily usable, and researchers resist putting all the "bells and whistles" on a code that's already quite technically sound. Even perceived difficulties with applications software are sufficient for industry to look elsewhere for a validated product to solve its problem. Because of the lack of financial incentive to both research and design communities, the overlap between them, where cooperative joint technology translation and

validation should occur, is missing. An obvious solution lies in having a third party perform the translation step.

The technology translation process involves two critical activities: the analysis of end-user needs and the validation of selected technologies. The first step in the process is the identification of the needs and requirements of the end-user. Since most of the technology developed in an R&D setting such as the National Labs is not in direct response to user specifications or requirements, available technologies rarely satisfy user needs.

The analysis of user specifications and requirements identifies the specific technology requirements that have to be met by available (or modified) technology. This analysis leads to the selection of the appropriate technology for re-engineering, modification or upgrading. This translation of the technology into the appropriate form is the first critical step, one that is rarely performed in an R&D setting for it is more appropriate to an engineering development environment.

Once the technology has been selected and translated into the user required form, the next step is the verification and validation of the software package over the intended range of use. If the intended application of the software package is in a narrow range, then the technology need only be calibrated at the point(s) of principal usage. The calibration process, see Reference B-3, can produce empirical modifications to the technology for improved accuracy at the point(s) of use. The calibration process is less costly and less time consuming than full validation.

The full validation of the software technology over the range of intended use can be a resource intensive process that requires usage of standard industry test management procedures. This requires the adoption of standard quality management practices and is a process that is rarely acceptable to the R&D community. In fact, it is inappropriate to utilize R&D personnel to perform routine engineering duties. However, these routine software engineering practices are critical to producing robust, commercial quality level software from R&D research codes.

The final step in the technology translation process is the transfer of the technology to the end user organization.

References

- B-1 "The Federal High Performance Computing Program," Executive Office of the President, Office of Science and Technology Policy, September 8, 1989.
- B-2 Graves Jr., R.A., Sridhar, K.P., and Murphy, C.G., "Technology Translation: Creating the Infrastructure for Successful Technology Transfer," Management White Paper No. 11, RCI Ltd., Minneapolis, July 1992.
- B-3 Graves Jr., R.A., "Software Validation: The Bridge from R&D to Industrial Application," AIAA Paper 92-0587, 30th Aerospace Sciences Meeting, January 1992, Reno, Nevada.

This Page Left Intentionally Blank

APPENDIX C

Laboratory Capabilities/Technology Briefing

This Page Left Intentionally Blank

HPCC Technology Awareness Program

Energy Research—Computational Sciences—Pilot Project

- ◆ **Purpose: Enhance the relationship of DOE National Laboratories and their HPCC effort with industry**

For further information contact:
Dr. Randy Graves or Dr. Carl Murphy
IG Technologies
5090 Shoreham Place, Suite 109
San Diego, CA 92122
619-558-9283; FAX 619-558-9285

DOE GRANT #DE-FG03-93ER25149/A000

Leverage for Industry in World Competitiveness

The Technology Awareness program can leverage your R&D efforts by using National Laboratory technology, people, facilities, and knowledge.

◆ **This represents an opportunity for:**

- ▣ locating new technologies
- ▣ enhancing your R&D dollar
- ▣ lowering your R&D risk
- ▣ shortening development time scale
- ▣ increasing your product effectiveness

Focus on Computation Communication and Multidisciplinary Needs

The best use of the capabilities may well be in using multidisciplinary teams from the DoE National Laboratories..

- ☛ Concentrates on High Performance Computing and Communications portion
- ☛ Energy Research funding of DOE Laboratories (not the Defense Research)
- ☛ Not limited exclusively to computer science and communication projects
- ☛ Other R&D needs that you make known to us could be important

Cooperative R&D Program

The process leads to a cooperative R&D effort to enhance your product, process, tool, or your vendor's value to your productivity.

◆ **Goals are:**

- ☞ to identify company, industry, or national needs that could be enhanced through partnership with the Laboratories
- ☞ establish a pilot program that allows the technology skills, resources, facilities, and technology to be used in increasing US competitiveness
- ☞ make that program a success in improving your effectiveness in competing on a global basis

Possible R&D Applications Areas

◆ Engineering Design Automation

- ☞ Application setup
- ☞ Numerical and computational methods
- ☞ Computation
- ☞ Analysis and visualization
- ☞ Interface to the production process

◆ Process

- ☞ Concurrent engineering process
- ☞ Decision tools
- ☞ Test and inspection automation
- ☞ Technology competitive evaluation & prognosis;

Possible R&D Applications Areas

◆ Facilities

- ▣ Porting of common tools to parallel systems
- ▣ Transition to engineering application from research
- ▣ Use of Laboratory computational facilities for acceleration of problem solution
- ▣ Embedded computational methods and tools;
- ▣ Operation in the factory or production facility
- ▣ Communications systems for office, plant, factory

◆ Methods for Collaboration

- ▣ Information sources at Laboratories
- ▣ Direct technology transfer
- ▣ Cooperative and supportive research based on industry needs;
- ▣ Consortia working with the Laboratories

Risk Sharing to Reach Competitive Levels

Some extremely valuable ideas may require high technical risk R&D that is not consistent with competitive forces and market risks in an industry;

- ☞ The process of cooperative R&D allows commercial firms to share technical risk and reduce funding, market, and acceptance risks
- ☞ The Nation benefits through creation of useful products that could not have been created otherwise.

The Cooperative R&D Process

(example program)

Industry Innovator	National Laboratory
Product Conceptualization & Definition	Identify Related Capability, Facility & Interest
Product R&D Requirements	R&D Plan
Manage R&D Effort (Product Focus) Conduct Low Risk R&D	Conduct High Risk R&D Component
Transform R&D into Product (Market Evaluation and Feedback)	Integration of Technology with Commercial Needs
Validation	Evaluation of Test and Validation Studies
Commercialization	Possibly: Refinement of R&D for Robustness
Marketing and Sales	Continue Related R&D
New Cycle Based on Product Acceptance and Feedback	New Cycle of R&D

HPCC Technology Awareness

- ☞ Identify and Make Industrial Contacts
- ☞ Define Technology Needs/Evaluate Value
- ☞ Identify Matching Capabilities at National Laboratories
- ☞ Definition of R&D and Product Concept for National Laboratory and Industrial Contacts
- ☞ Assist Cooperative R&D Agreement Process
- ☞ Assist in Market Evaluation and Feedback
- ☞ Act as Industry Consortium focus to solve industry-wide needs

HPCC Technology Awareness (cont.)

- ☞ Define Cooperative R&D Project/Identify Risks
- ☞ Aid by Monitoring & Evaluation of Quality at Each Step
 - *r&d*
 - *product transformation*
 - *validation*
 - *commercialization*
- ☞ Validation of Technology Produced at National Laboratories—Testing for Completeness and Robustness
- ☞ Commercialization—Assist with Integration into Product Line
- ☞ Evaluation of Critical Decisions and Paths—Input to future technology awareness process

Department of Energy Cooperative Research and Development Agreements

CRADAs

	<u>CRADA's</u>	<u>% of Total</u>
Total CRADAs in Place (May 1993)	393	100
Computing Related CRADAs	50	13
Software Related	23	6
<ul style="list-style-type: none">• Applications Software (16)• Systems Software (7)		
Hardware Related	25	6.5
Networking Related	2	.5

*** CURRENT HIGH-PERFORMANCE COMPUTING RELATED CRADA's**

National Lab/Industry	Title
SNL/Intel Corporation	Parallel Computing C++ Mathematical Libraries
LLNL/Varian Associates, Inc.	Trilayer Josephson Junctions produced by Atomic Layer by Layer MBE
SNL/Radiant Technologies, Inc.	Ferroelectric Read/Write Optical Disc
SNL/Advanced Micro Devices, Inc.	Assessing and Improving the Reliability of New Integrated Circuit Manufacturing Technologies
LANL/Thinking Machines Corp.	Algorithms and Software for Massively Parallel Computing Systems
PNL/Computervision Corp.	Spatial Statistics/Information Management Initiative with Computervision
PNL/Intel, Corp., Supercomputer Systems Division	Interprocessor Communications in Massively Parallel Supercomputers
SNL/BIOSYM Technologies, Inc.	Parallel Numerical Libraries for Materials Modeling Programs
LANL/General Motors Corp., Research and Environmental	Numerical Modeling of the Mechanics of Machining
SNL/Photonics Imaging	Plasma Panel Materials Development and Modeling for Higher Efficiency Devices
SNL/AT&T	XUNET Experimental High-Speed Network Testbed
SNL/Cray Research, Inc.; E.I. Du Pont de Nemours & Co.; Bristol Meyers Squibb, Pharmaceutical Research Inst.	Massively Parallel Simulation of Large Molecular Systems with Long-Range Interactions
LLNL/AT&T Bell Labs	Gigabit Network Technology
SNL/Motorola, Inc.	Advanced Compound Semiconductor Heterostructures and Materials for High-Performance Digital Microelectronics

*As of May 1993

c:\mosaic\thayes\cradarpt.lst

SNL/Cray Research, Inc.	Massively Parallel Electronic Structure Methods for Cray's MP Supercomputer
SNL/Motorola, Inc., Semiconductor Products Sector	Advanced SiGeC Materials for High-Performance Digital Microelectronics
LLNL/MRS Technology, Inc.	Transport System for Manufacturing Flat-Panel Displays
SNL/Analog Devices, Inc.	Assessing and Improving the Reliability of New Integrated Circuit Manufacturing Technologies
LLNL/MRS Technology, Inc.	Illumination Source for Flat Panel Lithography Program
ORNL/IBM	Developing Advanced Metallization Technology for Processing Integrated Circuits with Submicron Features
ANL/Allied-Signal, Inc.	Parallel Implementation of Molecular Mechanics Software
ORNL/IBM	Evaluation and Performance Assessment of Advanced Computing Architectures
LANL/Amoco Oil Co., Research and Development	Supercomputer Simulation Model for Residual Oil Hydroprocessing Reactors
LLNL/Zitel Corporation	National Storage Laboratory Collaboration
LLNL/Maximum Strategy Corp.	National Storage Laboratory Collaboration
LLNL/Network Systems Corp.	National Storage Laboratory Collaboration
LLNL/General Atomics	National Storage Laboratory Collaboration
LLNL/Ampex Corporation	National Storage Laboratory Collaboration
LLNL/IBM Federal Systems, Co.	National Storage Laboratory Collaboration
BNL/Plasma Physics Corporation	Methods for Production of a New Silicon Material Silicon On Defect Layer (SODL)
LLNL/Hewlett-Packard Co.	Interconnection Technology for Ultra-High Performance Multichip Modules

*As of May 1993

c:\mosaic\thayes\cradarpt.lst

LLNL/Cray Research, Inc.	Massively Parallel Computing Initiative Cooperative Project
SNL/SEMATECH	Microelectronics Manufacturing Technology
ORNL/Intel Supercomputer Systems Div.	Evaluation of Prototype Systems
SNL/PDA Engineering	MESH Generation Software Research and Development
SNL/AT&T Bell Labs	Projection X-Ray Lithography Using a Laser Plasma Source
SNL/Fluid Dynamics International, Inc.	MESH Generation Software Research and Development
SNL/MacNeal-Schwendler Corp.	MESH Generation Software Research and Development
SNL/Ford Motor Co., CAE Dept.	MESH Generation Software Research and Development
LANL/Cray Research, Inc.	Computational Electromagnetics for Electronics Design
LANL/Cray Research, Inc.	Computational Chemistry
SNL/General Electric	Synthetic Diamond Substrates for Electronic Multichip Packaging
SNL/SEMATECH	Benchmarking Microelectronics Manufacturing Equipment
SNL/LSI Logic Corporation	Assessing and Improving the Reliability of Integrated Circuit Manufacturing Technologies
LANL/Motorola, Inc.	Application and Stimulation of Dataflow Computers
SNL/Signetix Corporation	Assessing and Improving the Reliability of New Integrated Circuit Manufacturing Technologies
SNL/National Semiconductor Corp.	Assessing and Improving the Reliability of Integrated Circuits with Emphasis on Gate Oxide Quality
ORNL/KLA Instruments Corp.	Semiconductor Yield Improvement Through Automated Defect Classification
SNL/SEMATECH	Semiconductor Manufacturing Technologies

*As of May 1993

c:\mosaic\thayes\cradarpt.lst

Argonne National Laboratory

Major Programs

- High-Performance Computing
 - Organizer: High-Performance Computing Research Consortium
 - Member: Concurrent Supercomputing Consortium, NSF Center for Research in parallel Computation
- Computational Chemistry
- Computational Biophysics
- Geophysical Modeling
- Superconductivity
- Linear Algebra
- Optimization
- Advanced Manufacturing Technologies
 - Modeling, Simulation, and Design
 - Advanced Materials Applications
 - Process Development
- - Advanced Sensor Development/Quality Control Technologies

Advanced Facilities

- High-Performance Computing Research Facility
- Mechanical Properties Testing Laboratory
- Thermal Science Laboratory

Argonne National Laboratory

	Applied	Basic
<u>Computing Technologies</u>	<u>R&D</u>	<u>R&D</u>
<u>Climate Modeling</u>		
• Advanced Algorithms, Climate Model Physics	√	√
• Massively Parallel Computing (Regional Weather Modeling, Global Climate Modeling)	√	
<u>Molecular Engineering</u>		
• Molecular Structure (Computational Biophysics and Computational Chemistry)	√	√
• Scalable Algorithms for Massively Parallel Computing	√	
<u>Superconductivity</u>		
• Vortex Dynamics and Structures	√	√
• Numerical Simulation	√	√
• Massively Parallel Computing		
<u>Optimization</u>		
• Advanced Algorithms	√	√
• Software (MINPACK-2, ADIFOR)	√	
• Automatic Differentiation - Design Optimization, Sensitivity Analysis	√	√

Argonne National Laboratory

<u>Computing Technologies (Continued)</u>	<u>Applied R&D</u>	<u>Basic R&D</u>
---	----------------------------	--------------------------

Advanced Tools and Techniques

• p4 (Portable, Low-Level Communications Library)	√	√
• PCN Toolkit (High-Level Parallel Programming Language)	√	
• Fortran M: Modular Task-Parallel Programming	√	√
• Software Tools (Programming/Performance Monitoring)	√	√
• PETSc - Portable, Extensible Tools for Scientific Programming	√	

Visualization

• Distributed Parallel Graphics	√	√
• Dynamic Interaction	√	

Advanced Manufacturing

• Metal Casting Simulation	√	
• Mechanical Mechanisms Modeling	√	
• Structural Dynamics/Deformations (Crashworthiness, etc.)	√	√
• Production Process Simulation	√	
• Molecular Design (Pharmaceutical, Agricultural, and Chemical)	√	

Argonne National Laboratory

Computational Modeling Examples

Climate Modeling (Massively Parallel Mesoscale Model)	Short-Range Weather Prediction Storm Modeling Climatic Change Simulation
Protein Design	Macromolecular Modeling Protein Folding Protein-Protein Interactions
Optimization Software (MINPACK-2)	Systems of Nonlinear Equations, Nonlinear Least Squares, Problems, and General Minimization
Optimization Software (ADIFOR)	Automatic Differentiation Applications in CFD, Heart Transplant Rejection Modeling, and Lubrication and Friction Simulation
Metal Casting (Casting Process Simulation: CAPS)	Mold Flow Simulation Heat Transfer
Manufacturing Process Simulation (General Purpose Simulator: GPS)	Rapid Prototyping of Production Processes Systems Analysis
Environmental Remediation	Parallel Methods and Modeling Systems for Cleaning Up Hazardous Wastes and Incineration of Halohydrocarbons

Lawrence Livermore National Laboratory

<u>Computing Technologies</u>	Applied R&D	Basic R&D
<u>Hierarchical Data Storage</u>		
• Database Systems	√	√
<u>Gigabit Networking</u>		
• Networks & Communications	√	√
<u>Evaluation of Processor Architectures</u>		
• Processor Architectures	√	
<u>Visualization</u>		
• Visualization Laboratory	√	√
• Multimedia Interfaces	√	√
• Virtual Reality	√	

Lawrence Livermore National Laboratory

<u>Computing Technologies (Continued)</u>	<u>Applied R&D</u>	<u>Basic R&D</u>
<u>Software Engineering</u>		
• Parallel Systems	√	
• Re-engineering	√	
<u>Operating Systems</u>		
• Parallel Computing	√	
• Distributed Computing	√	
<u>Modeling and Simulation</u>		
• Computational Fluid Dynamics	√	√
• Electromagnetic Phenomena	√	√
• Structural Mechanics	√	√
• Materials		
- Synthesis and Processing	√	√
- Analysis	√	√
• Atmospheric Modeling		
- Atmospheric General Circulation Model (Parallel Processing Code)	√	√

Lawrence Livermore National Laboratory

<u>Computing Technologies (Continued)</u>	<u>Applied R&D</u>	<u>Basic R&D</u>
<u>Mathematical Software Service</u> <ul style="list-style-type: none">Libraries	√	
<u>Numerical/Applied Mathematics</u> <ul style="list-style-type: none">Algorithms/Methodologies	√	√

Lawrence Livermore National Laboratory

Modeling and Simulation Examples

COG: A Transport Code	High resolution monte carlo neutron-photon transport code for shielding, criticality and activation
DYNA3D	A nonlinear structural dynamics code to analyze complex structural response of mechanical systems to high-rate loadings and impacts.
NIKE2D and NIKE3D	Analysis of the mechanical response of structures due to vibration, low-velocity dynamics, and static loadings.
TOPAZCHM	A heat transport code that incorporates arbitrary chemistry of mixed materials, internal heat generation, nonisotropic thermal conductivity and a variety of boundary conditions.
PALM2D	A structural response analysis, MIKE2D, combined with a heat transport code, TOPAZ2D, to more accurately model thermal stress problems in two dimensions.
ARAC	A package of two computer codes to predict the movement of particles or pollutants over real landscapes.

Lawrence Livermore National Laboratory

Modeling and Simulation Examples (Continued)

EQ3/6	Modeling of geochemical processes that result from the interactions among rocks, groundwater, air and waste products.
FEM3A	A modeling code to predict the dispersion of heavier-than-air clouds from hazardous spills.

Los Alamos National Laboratory

Major Initiatives

- High Performance Computing (A DOE Center)
- High Temperature Superconductivity
- Advanced Research Centers:
 - Nonlinear Studies
 - Materials Science
 - Computational Testbed for Industry
 - Human Genome Studies
 - National Security Studies
 - Geophysics and Planetary Physics
- Nuclear Defense
- Conventional Defense

Advanced Facilities

- Research in Advanced Computing
- Meson Physics Research
- Neutron Scattering Research

Los Alamos National Laboratory

<u>Computing Technologies</u>	Applied R&D	Basic R&D
-------------------------------	----------------------------	--------------------------

Distributed High Performance Computing

• Database Systems		√
• Networks & Communications	√	√
• Operating Systems	√	√
• Software Engineering	√	√

Architectural Simulation Facility

• Operating Systems	√	√
• Software Engineering	√	√

Computing Environments for Parallel Workstations

• Networks & Communications	√	√
• Operating Systems	√	√
• Software Engineering	√	√
• Visualization	√	√

Los Alamos National Laboratory

<u>Computing Technologies (Continued)</u>	Applied	Basic
	R&D	R&D
<u>Optical Networks</u>		
• Networks & Communications	√	√
<u>Database Management</u>		
• Database Systems	√	√
<u>Modeling and Simulation</u>		
• Materials Science (Structure, Properties, Electronics, Polymers & Biological, and Composites)	√	√
• Chemistry and Physics (Chemistry, Physics, and Atmospheric Science)	√	√
• Nuclear Science	√	√
• Mathematical Modeling (Algorithms, Signal and Data Processing, Optimization and Process Modeling)	√	√
• Engineering Modeling (General and Continuum Mechanics)	√	√
• Transport of Energy, Mass and Momentum (General, Flow & Transport in Porous Media)	√	√
• Energy, Environment and Economics	√	√

Los Alamos National Laboratory

Computational Modeling Examples

Optoelectronics	Self-consistent 3-D particle and photon transport Materials deposition in 3-D process modeling and simulations Material microstructures Novel materials
Structural Acoustics	Simulation of sound propagation Noise suppression and vibration control
Mechanics of Machining and Metal Forming	Mechanics of machining and metal forming Constitutive property development and applications
Biomechanics	Radial Keratectomy for correcting myopia
Behavior of Complex Materials	Concrete, rocks, H ₂ diffusion in metals, and fluid migration Simulations of structural collapse, mantle convection, earthquake rupture, strength degradation from corrosive effects, and formation of oil traps in geological structure
Structural/Design	Large structure modeling, design, and finite element analysis Nonlinear material properties; coupled thermal/mechanical analysis Modal analysis; impact/crash -- low and high velocity, hydro

Los Alamos National Laboratory

Computational Modeling Examples (Continued)

Metal Forming	Mechanics of materials in metal forming Constitutive property development and applications simulations
Dynamics: Solid & Hydro	Simulation of complex multibody interactions Heat transfer with reactive materials Fully integrated hydro/structural analysis with MESA and ABAQUS
High Voltage System Modeling	Component design (bushings, columns, lenses) of high voltage systems utilizing multiple dielectrics or magnetic materials Steady-state or pulsed (2D or 3D) simulation capability

Oak Ridge National Laboratory

Major Initiatives

- High Performance Computing (A DOE Center)
- Ground Water Transport and Remediation
- Materials Simulation, Design, and Manufacturing Technologies
- Global Change Simulation
- Advanced Energy Systems
- Center for Environmental Technology
- Focused Research Centers
 - Engineering Systems
 - High Temperature Materials
 - National Environmental Research Park
- Center for Biological Sciences
- Transportation Technologies and Systems

Advanced Facilities

- Center for Computational Sciences
 - High Performance Computing Research Center
- Neutron Scattering Research
 - Advanced Neutron Source

Oak Ridge National Laboratory

	Applied	Basic
<u>Computing Technologies</u>	R&D	R&D
<u>Distributed Operating Systems and Tools</u>		
• Networks and Communications	√	√
• Operating Systems	√	√
• Software Engineering	√	√
<u>Evaluation of Early Systems</u>		
• Database Systems	√	√
• Processor Architecture	√	√
• Networks and Communications	√	√
• Human Interfaces	√	
• Visualization	√	
• Operating Systems	√	
• Software Engineering	√	√
<u>Networks and Communications</u>		
• Gigabit Networking	√	√

Oak Ridge National Laboratory

<u>Computing Technologies (Continued)</u>	Applied R&D	Basic R&D
---	----------------------------	--------------------------

<u>Software Engineering</u>		
-----------------------------	--	--

• Parallel Algorithms	√	√
• Programming Tools	√	√
• Distributed Operating Systems	√	
• Interactive Visualization	√	√
• Visualization Tools/Techniques	√	

Oak Ridge National Laboratory

Focused "Grand Challenge" Activities

Groundwater Transport and Remediation	Development and testing of a parallel, 3D transport and flow code that accounts for front-tracking, bioremediation, radionuclide decay, multiphase flow and chemical reactions.
Materials Simulation	Develop new methods for performing large scale simulations of materials properties using a hierarchy of increasingly more accurate techniques: classical potentials, tight-binding models and ab-initio quantum mechanical methods.
Global Change Simulation	Parallelization of global climate models to provide increased spatial resolution and faster turn around times with an emphasis on the atmosphere. Develop more comprehensive models using coupled atmospheric and oceanic global climate dynamics.

Sandia National Laboratories

Major Initiatives

- Massively Parallel Computing
- Materials Science
- Combustion Research
- Energy Systems

Advanced Research Centers

- Center for Synthesis and Processing of Advanced Materials
- Center for Solder Science
- Semiconductor Equipment Technology Center
- Microelectronics Quality/Reliability Center

Advanced Facilities

- Combustion Research Facility
- Annular Core Research Reactor
- Microelectronics Development Laboratory
- Massively Parallel Computing Laboratory

Sandia National Laboratories

<u>Computing Technologies</u>	<u>Applied R&D</u>	<u>Basic R&D</u>
High Performance Parallel Computing/Computational Science	√	√
• Scalable Parallel Algorithms		√
• Parallel Computing Libraries		√
• Parallel Computing Operating Systems	√	√
• Parallel Computing Utilities/Programming Environments	√	√
• Parallel Languages and Computers		√
Advanced Computer Architectures		
• Multithreaded Operating Systems		√
• Data Flow Architectures	√	√
• Parallel Digital Signal Processing	√	√

Sandia National Laboratories

	Applied	Basic
<u>Computing Technologies</u>	<u>R&D</u>	<u>R&D</u>

Networking

- High Speed Networking Technologies
- Distributed Computing Software
- Test Beds

√	
√	√
√	

Networking Security

- Software
- Synchronization Loss Detection
- Crypto Algorithms

√	√
√	√
	√

Visualization

- Advanced Visualization
- Parallel Visualization Software

√
√

Sandia National Laboratories

Computational Modeling Examples

Computer Aided Molecular Design	Design and Simulation of Advanced Catalysts Analysis of Polymers and Polymer Blends Analysis of Polymers and Polymer Blends
Electromagnetic Modeling of Integrated Circuit Structures (QUICKSILVER Code)	Time-dependent, Full-wave Simulations High Frequency Characterizations of Chips and Innerconnections
Grid Generation Algorithms	Quadrilateral Meshes on 3-D Surfaces Hexahedral Meshes for 3-D Solids Adaptive Finite-element Meshes
Computational Modelling of Investment Casting (FAST CAST, COYOTE, CHAPARRAL, JAC3D and SATOS Codes)	Nonisothermal Mold Filling Solidification, Shrinkage and Porosity Residual Stress Prediction Warpage
Chemically Reacting Flows (Chemkin Code)	Gas Phase and Surface Chemistry Reactions Flames, Combustion and Explosions Chemical Vapor Deposition and Surface Films
Sandia Pulse Combustor Design Code	High Frequency Combustion Analysis Time-dependent Fluid Dynamics Mining and Heat Release Analysis

HPCC Laboratory Contacts

Argonne National Laboratory

Tom Morgan
(708) 252-5218
FAX: (708) 252-5986

HPCC Program
Argonne National Laboratory
MCS/Bldg. 221
9700 S. Cass Avenue
Argonne, IL 60439-4843

Los Alamos National Laboratory

David Cartwright
(505) 667-3612
FAX: (505) 672-1572

ADCIS, MS-A110
Los Alamos National
Laboratory
Los Alamos, NM 87545

Lawrence Livermore National Laboratory

Hank Shay
(510) 422-4677
FAX: (510) 423-4820

L-66
Lawrence Livermore National
P.O. Box 808
Livermore, CA 94550

Oak Ridge National Laboratory

Ken Kliever
(615) 241-2859
FAX: (615) 241-2850

Bldg. 4500 North/MS 6203
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831

Sandia National Laboratories

Sudip Dosanjh
(505) 845-7018
FAX: (505) 845-7442

Mail Stop 1402
Sandia national Laboratories
Albuquerque, NM 87185

HPCC Technology Awareness Contacts

Roger Webb
IG Technologies
C/O Gateway Technologies International, Inc.
800 Silverado Street, Suite 303
La Jolla, CA 92037
(619) 454-6534
FAX: (619) 454-6053

Randy Graves
IG Technologies
C/O Mosaic Multisoft Corporation
5090 Shoreham Place, Suite 109
San Diego, CA 92122
(619) 558-9283
FAX: (619) 558-9285

Carl Murphy
IG Technologies
C/O CHoPP Computer Corporation
5080 Shoreham Place, Suite 200
San Diego, CA 92122
(619) 622-0680
FAX: (619) 622-0682

APPENDIX D

Sample Cooperative Research and Development Agreement (CRADA)

This Page Left Intentionally Blank

TABLE OF CONTENTS

ARTICLE I.	<u>DEFINITIONS</u>	2
ARTICLE II.	<u>STATEMENT OF WORK</u>	3
ARTICLE III.	<u>FUNDING & COSTS</u>	3
ARTICLE IV.	<u>PROPERTY</u>	3
ARTICLE V.	<u>DISCLAIMER AND REPRESENTATIONS</u>	3
ARTICLE VI.	<u>PRODUCT LIABILITY</u>	4
ARTICLE VII.	<u>OBLIGATIONS AS TO PROPRIETARY INFORMATION</u>	5
ARTICLE VIII.	<u>OBLIGATIONS AS TO PROTECTED CRADA INFORMATION</u>	6
ARTICLE IX.	<u>RIGHTS IN GENERATED INFORMATION</u>	6
ARTICLE X.	<u>EXPORT CONTROL</u>	6
ARTICLE XI.	<u>REPORTS AND ABSTRACTS</u>	7
ARTICLE XII.	<u>PRE-PUBLICATION REVIEW</u>	7
ARTICLE XIII.	<u>COPYRIGHT AND MASK WORK RIGHTS</u>	7
ARTICLE XIX.	<u>REPORTING INVENTIONS</u>	9
ARTICLE XV.	<u>TITLE TO INVENTIONS</u>	9
ARTICLE XVI.	<u>FILING PATENT APPLICATIONS</u>	10
ARTICLE XVII.	<u>COST OF INTELLECTUAL PROPERTY PROTECTION</u>	10
ARTICLE XVIII.	<u>REPORTS OF CRADA TECHNOLOGY USE</u>	11
ARTICLE XIX.	<u>DOE MARCH-IN RIGHTS</u>	11
ARTICLE XX.	<u>U.S. COMPETITIVENESS</u>	11
ARTICLE XXI.	<u>ASSIGNMENT OF PERSONNEL</u>	11
ARTICLE XXII.	<u>FORCE MAJEURE</u>	11
ARTICLE XXIII.	<u>ADMINISTRATION OF THE CRADA</u>	12
ARTICLE XXIV.	<u>RECORDS AND ACCOUNTING SYSTEM</u>	12
ARTICLE XXV.	<u>NOTICES</u>	12
ARTICLE XXVI.	<u>DISPUTES</u>	13
ARTICLE XXVII.	<u>ENTIRE CRADA AND MODIFICATIONS</u>	13
ARTICLE XXVIII.	<u>TERMINATION</u>	13
ARTICLE XXIX.	<u>PROJECT MANAGEMENT</u>	13

STEVENSON-WYDLER (15 USC 3710)
COOPERATIVE RESEARCH AND DEVELOPMENT
AGREEMENT (hereinafter "CRADA") NO. _____

BETWEEN

under its U.S. Department of Energy Contract
No. _____ (hereinafter "Contractor")

AND

_____ (hereinafter "Participant")

both being hereinafter jointly referred to as the "Parties"

ARTICLE I. DEFINITIONS

- A. "Government" means the United States of America and agencies thereof.
- B. "DOE" means the Department of Energy, and Agency of the United States of America.
- C. "Contracting Officer" means the DOE employee administering the Contractor's DOE contract.
- D. "Generated Information" means information produced in the performance of this CRADA.
- E. "Generated Information" means information which embodies (i) trade secrets or (ii) commercial or financial information which is privileged or confidential under the Freedom of Information Act (5 USC 552 (B)(4)), either of which is developed at private expense outside of this CRADA and which is marked as Proprietary Information.
- F. "Protected CRADA Information" means Generated Information which, if it had been obtained from a third party, would be Proprietary Information or would disclose Proprietary Information, and which has been designated in accordance with Article VIII as protected CRADA Information.
- G. "Subject Invention" means any invention of the Contractor or Participant conceived or first actually reduced to practice, as defined under the United States patent laws, in performance of work under this CRADA.
- H. "Background Intellectual Property" means intellectual property rights in the items identified by the Parties in Appendix D, Background Intellectual Property, which were in existence prior to this CRADA or are first produced or reduced to practice outside this CRADA and which may be used by the Parties in conducting the work under, but which are not the primary subject of, this CRADA. Licensing of Background Intellectual Property, if agreed to by the Parties, shall be the subject of separate licensing agreements between the Parties. Background Intellectual Properties are not Subject Inventions.
- I. "Intellectual Property" means patents, copyrights, trademarks and mask works protected by Federal Law and foreign counterparts.

ARTICLE II. STATEMENT OF WORK

Appendix A is the Statement of Work.

ARTICLE III. FUNDING & COSTS

A. Neither Participant's estimated contribution is \$ _____. The Government's estimated contribution, which is provided through the Contractor's contract with DOE, is \$ _____ subject to available funding.

B. Neither Party shall have an obligation to continue or complete performance of its work at a cost in excess of its estimated cost as contained in Article III A above, including any subsequent amendment.

C. Notification to all parties that actual costs will exceed estimated costs shall be provided by any Party who makes such determination. Such notification shall take place as soon as possible after making such determination, but not later than 30 days prior to termination based on such cause. If the parties mutually agree to continue the project, subject to Article XXVII, the estimated cost shall be appropriately amended and the Parties shall agree on the share of each Party of such increase in estimated cost by duly executed amendments to the CRADA.

D. If Participant agrees to contribute funds to the Contractor, then an advance payment provision will be negotiated.

ARTICLE IV. PROPERTY

All tangible personal property produced under this CRADA (specifically excluding Intellectual Property rights, Background Intellectual Property, and Proprietary Information) shall become the property of the Participant or the Government depending upon whose funds were used to obtain it. Such property is identified in Appendix A, Statement of Work. Personal Property shall be disposed of as directed by the owner at the owner's expense. There shall not be any jointly funded property under this CRADA except by the mutual agreement of the Parties.

ARTICLE V. DISCLAIMER AND REPRESENTATIONS

A. THE GOVERNMENT, THE PARTICIPANT, AND THE CONTRACTOR MAKE NO EXPRESS OR IMPLIED WARRANTY AS TO THE CONDITIONS OF THE RESEARCH OR ANY INTELLECTUAL PROPERTY OR PRODUCT MADE, OR DEVELOPED UNDER THIS CRADA, OR THE OWNERSHIP, MERCHANTABILITY OF FITNESS FOR A PARTICULAR PURPOSE OF THE RESEARCH OR RESULTING PRODUCT. NEITHER THE GOVERNMENT, THE PARTICIPANT, NOR THE CONTRACTOR SHALL BE LIABLE FOR SPECIAL, CONSEQUENTIAL OR INCIDENTAL DAMAGES.

B. Contractor represented that all prior reviews and approvals required by regulation or law have been obtained from DOE prior to the execution of this CRADA and that the Contractor official executing this CRADA has the requisite authority to do so.

C. Participant represents that it has the requisite power and authority to enter into the CRADA. The participant official executing his Agreement has the requisite authority to do so.

D. The Government through approval of this CRADA hereby gives its authorization and consent to Participant for all use and manufacture of any invention described in and covered by any U.S. Letters Patent in the performance of this CRADA or any part hereof or any amendment hereto or any subcontract hereunder, including all lower-tier subcontracts. Based upon such authorization and consent Participant shall indemnify the Government and its officers, agents and employees against all liability, including costs, for infringement of U.S. Letters Patent incurred during the term of this CRADA as a result of Participant's invocation of the above-provided authorization and consent. The foregoing indemnity shall not apply unless: 1) participant shall have been informed as soon as practicable by the Government of the claim of infringement, and shall have been given the opportunity, to the extent afforded by applicable laws, rules or regulations to participate and control in the defense thereof, and 2) the Contractor and Government shall have provided all reasonably available information and reasonable assistance requested by Participant and further, such indemnity shall not apply to: 1) a claimed infringement which is settled without the consent of Participant, unless required by final decree of a court of competent jurisdiction, 2) any Government or Contractor use of Generated Information in any form outside of the CRADA, or 3) any use by the Government or Contractor of modifications, enhancements and derivatives to Generated Information developed by the Government or Contractor outside of the CRADA.

ARTICLE VI. PRODUCT LIABILITY

A. Except for any liability resulting from any negligent or intentional acts or omissions of contractor, Participant indemnifies the Government and the Contractor for all damages, costs and expenses, including attorney's fees, arising from personal injury or property damage occurring as a result of the making, using or selling of a product, process or service by or on behalf of the participant, its assignees or licensees, which was derived from the work performed under this CRADA. In respect to this Article, neither the Government nor the Contractor shall be considered assignees or licensees of the Participant. The indemnity set forth in this paragraph shall apply only if Participant shall have been informed as soon and as completely as practical by the Contractor and/or Government shall have provided all reasonably available information and reasonable assistance required by Participant. No settlement for which Participant would be responsible shall be made without Participant's consent unless required by final decree of a court of competent jurisdiction.

B. For licenses granted by Contractor to any third party in Intellectual Property derived from Generated Information, such licenses shall include the requirement that the third party shall indemnify the Government, Contractor, and Participant for all damages, costs and expenses, including attorney's fees, arising from personal injury or property damage occurring as a result of the making, using or selling of a product, process or service by or on behalf of such third party, its assignees or licensees.

ARTICLE VII. OBLIGATIONS AS TO PROPRIETARY INFORMATION

A. Proprietary Information may be disclosed orally, electronically, visually or in a written or other tangible form. To the extent that any Generated Information divulges, duplicates or substantially duplicates Proprietary Information, such Generated Information shall be marked

and treated as Proprietary Information. If Proprietary Information is orally disclosed to a party, it shall be identified as such, orally, at the time of disclosure and confirmed in a written summary thereof within 30 days as being Proprietary Information.

B. Each Party agrees not to use Proprietary Information provided by another Party for any purpose other than that set forth in this CRADA or disclose such proprietary Information (which shall include any notes, extracts, analyses or materials which would disclose Proprietary Information) to anyone other than the CRADA Participant and Contractor without written approval of the providing Party, except to Government employees who are subject to 18 USC 1905. Disclosures of Proprietary Information to DOE employees shall occur only on site at the Contractor's facilities unless mutually agreed upon by the Parties. Contractor and DOE shall limit their respective internal disclosure of Proprietary Information to those employees or agents having a need to know such Information. All participant Proprietary Information and any notes, extracts, analyses or materials which are prepared by the DOE employees at the site of the Contractor's facilities that would disclose Participant Proprietary Information shall not be removed by DOE from the Contractor's facilities. Neither Contractor nor Participant shall convey Proprietary Information of the other Party to the DOE without the express written authorization of such other Party, and subject to terms and conditions approved by such other Party. Contractor and Participant will each promptly advise the owner of the Proprietary Information in writing of any unauthorized disclosure or use of Proprietary Information by any person.

C. Proprietary Information in tangible form shall be returned to the disclosing Party or destroyed with a certificate of destruction submitted to the disclosing party upon request by the disclosing Party during the term of the CRADA or upon termination or expiration of this CRADA, unless otherwise approved in writing by the disclosing party.

D. All information marked as Proprietary Information shall be protected by the recipient as Proprietary Information for a period of _____ years, unless and until such Proprietary Information shall become publicly known without the fault of the recipient, shall come into recipient's possession from a third party without an obligation of confidentiality on the recipient, shall be independently developed by recipient employees who did not have access to Proprietary Information, is intentionally released by the disclosing Party to a third party without restriction, or is released for disclosure with the written consent of the disclosing party.

E. In no case shall the Contractor provide Proprietary Information or materials to any person or entity for commercial purposes, unless otherwise agreed to in writing by each Party.

ARTICLE VIII. OBLIGATIONS AS TO PROTECTED CRADA INFORMATION

A. Each Party may mark as Protected CRADA Information, as defined in Article I, any Generated Information produced by its employees, and, with the agreement shall not be unreasonably withheld. The parties agree that Generated Information in the areas specified in Appendix A shall automatically be marked as Protected CRADA Information.

B. For a period of _____ [not to exceed five years] from the date Protected CRADA Information and to use the same degree of care and discretion, but no less than reasonable care and discretion, to avoid disclosure, publication or dissemination of such Information to a third party, as the Party employs for similar protection of its own information which it does not desire to

disclose, publish or disseminate except:

1. as necessary to perform this CRADA;
2. as requested by the DOE Contracting Officer to be provided to other DOE facilities solely for government use only at those DOE facilities with the same protection in place; or
3. as mutually agreed by the Parties in advance.

C. The obligations of paragraph B above shall end sooner for any Protected CRADA Information which shall become publicly known without fault of either Party, shall be independently developed outside of the CRADA by a Party's employees who did not have access to the Protected CRADA Information, or is disclosed through product released by Participant. If recipient receives any information independently developed by a third party without any obligation of confidentiality which is similar to Protected CRADA Information, disclosure by recipient of such third party information shall not be a breach of this CRADA.

ARTICLE IX. RIGHTS IN GENERATED INFORMATION

The Government and Participant shall have unlimited rights in all Generated Information provided by the Parties under this CRADA which is not disclosed in a Subject Invention disclosure, protected as a mask work right, or marked as being copyrighted, Protected CRADA Information, or Proprietary Information.

ARTICLE X. EXPORT CONTROL

THE PARTIES UNDERSTAND THAT MATERIALS RESULTING FROM THE PERFORMANCE OF THIS CRADA MAY BE SUBJECT TO EXPORT CONTROL LAWS AND THAT EACH PARTY IS RESPONSIBLE FOR ITS OWN COMPLIANCE WITH SUCH LAWS.

ARTICLE XI. REPORTS AND ABSTRACTS

The Parties agree to provide the following deliverables to DOE:

1. nonproprietary abstracts (initial, final when work is complete, and others as substantial changes in scope and dollars occur);
2. a final report subject to Article VII and Article VIII; and
3. other topical/periodic reports subject to Article VII and Article VIII where the nature of research and magnitude or dollars justify.

ARTICLE XII. PRE-PUBLICATION REVIEW

A. The Parties anticipate that their employees may wish to publish technical developments and/or research findings generated in the course of this CRADA. On the other hand, the Parties recognize that a principal objective of this CRADA is to provide business advantages to Participant. In order to reconcile publication and business concern, the Parties agree to a review procedure as follows:

1. Each Party ("Submitter") shall submit to the other Party ("Recipient"), in advance, proposed written and oral publications pertaining to work under the CRADA. Proposed oral publications shall be submitted to Recipient in the form of a written presentation synopsis and a written abstract.
2. Recipient shall provide a written response to the Submitter within thirty (30) days, either objecting or not objecting to the proposed publication. Submitter shall consider all objections of Recipient and shall not unreasonably refuse to incorporate the suggestions and meet the objections of Recipient. The proposed publication shall be deemed not objectionable, unless the proposed publication contains Proprietary Information, Protected CRADA Information, or material that would create potential statutory bars to filing the United States or corresponding foreign patent applications in which case express written permission shall be required for publication.

B. The Parties agree that neither will use the name of the other Party or its employees in any promotional activity, such as advertisements, with reference to any product or service resulting from this CRADA, without prior written approval of the other Party.

ARTICLE XIII. COPYRIGHT AND MASK WORK RIGHTS

A. Contractor represents that DOE releases or has released to Contractor and Participant any rights it may have in the copyrights or mask work rights in any Generated Information, other than those referenced as belonging to DOE herein.

B. All Participant and Contractor copyrights and mask work rights to original information for which authorship takes place during the performance of work under this CRADA shall be owned and licensed as set forth in Appendix C, subject to any obligation of protection as required in Articles VII and VIII and other provisions of this Article.

C. For Generated Information other than the computer software covered by paragraph E of this Article, the Contractor and the participant agree that the Government has for itself and others acting on its behalf, a royalty-free, nonexclusive, irrevocable worldwide copyright license to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government for non-commercial purposes, all such copyrightable works produced in the performance of this CRADA, subject to the protection provided under this CRADA for Proprietary Information and Protected CRADA Information.

D. For all copyrighted computer software produced in the performance of this CRADA and covered by paragraph C of this Article, the Party owning the copyright will provide the source code, an expanded abstract as described in Appendix B, the object code, and the minimum support documentation needed by a competent user to understand and use the software to DOE's Energy Science and Technology Software Center ("ESTSC"). The expanded abstract will be treated in the same manner as Generated Information in paragraph C of this Article.

E. For computer programs agreed by Participant and Contractor as being developed principally for commercialization by the Participant and listed in Appendix E or a modification to this Appendix pursuant to Article XXVII, the Party owning the copyright will provide an expanded abstract as described in Appendix B to DOE's ESTSC. Source code developed solely by Participant shall be owned and retained by Participant and shall not be subject to delivery to Contractor or Government. Source code developed solely by Contractor, or jointly developed by Contractor and Participant, shall be first offered to Participant through an exclusive or nonexclusive license, at Participant's choice, under fair, reasonable, and appropriate terms as set forth in Appendix C. For all computer programs covered by this paragraph, the object code and the minimum support documentation needed by a competent user to understand and use the software ("Usage Package")

will be delivered to Contractor to use for non-commercial purposes and will be provided to ESTSC for licensing only to other DOE contractors (with Participant named as a third party beneficiary under such license for enforcement of the restricted use provisions) for only non-commercial use solely under their contracts with DOE in accordance with this Article and Appendix C and under the Disclaimer provisions of Article V. Participant shall make available to ESTSC, at its request, any maintenance releases of the Usage Package created by Participant for a period of two years after the development of the Usage Package. The Contractor and the Participant agree that the Government has for itself and others acting on its behalf a royalty-free, nonexclusive, irrevocable worldwide license to reproduce, and perform publicly and display publicly, by or on behalf of the Government for non-commercial purpose, the Usage Package, subject to the restrictions this CRADA places on publication of Proprietary Information and Protected CRADA Information and subject to the further restriction that neither the Government nor its contractors may decompile or reverse assemble the object code.

F. The Contractor and the Participant agree that with respect to any copyrighted computer software produced in the performance of this CRADA and covered by paragraph C of this Article or produced by Contractor and covered by paragraph E of this Article, DOE has the right, at the end of the period set forth in paragraph B Article VIII hereof and at the end of each two year interval thereafter, to request the Contractor and the Participant and any assignee or exclusive licensee of the copyrighted software to grant a nonexclusive, partially exclusive, or exclusive license to a responsible applicant upon terms that are reasonable under the circumstances, provided such grant does not cause a termination of Participant's or any licensee's right to use the copyrighted computer software under the terms of its license. If the Contractor or the Participant or any assignee or exclusive licensee refuses such request, the Contractor and the Participant agree that DOE has the right to grant such license if the Contractor, the Participant, assignee, or licensee has not made a satisfactory demonstration that it is actively pursuing commercialization of the copyrighted computer software, in light of all of the pertinent circumstances and conditions.

Before licensing under this paragraph F, DOE shall furnish the Contractor/Participant written notice of its intentions to grant the stated license, and the Contractor/Participant shall be allowed 30 days (or such longer period as may be authorized by the cognizant DOE Contracting Officer for good cause shown in writing by the Contractor/Participant) after such notice to show cause why the license should not be granted.

As set forth in paragraphs (b)-(g) of 10 CFR 781.65, "Appeals", the Contractor/Participant shall have the right to appeal to the Invention Licensing Appeals Board the decision by the DOE to grant the stated license.

G. The Parties agree and Contractor represents that the Government has agreed to place copyright and other notices, as appropriate for the protection of copyright and mask work rights, in human readable form onto all physical media, and in digitally encoded form in the header of machine readable information recorded on such media such that the notice will appear in human readable form when the digital data is off loaded or the data is accessed for display or printout.

ARTICLE XIV. REPORTING INVENTIONS

A. The Parties agree to disclose to each other through the Project Managers each and every Subject Invention which may be patentable or otherwise protectable under the Patent Act within two (2)

months, or such longer period as is reasonably required, after the inventor first discloses the invention in writing to the person(s) responsible for patent matters of the disclosing Party. The Contractor will disclose such inventions to the DOE in accordance with its prime contract.

B. These disclosures, to the extent known, shall be in such detail as to be capable of enabling one skilled in the art to make and use the invention under 35 USC 112 and shall also identify any events that could give rise to a statutory bar (i.e. printed publications describing the invention or the public use or on sale of the invention in this country). The Parties further agree to disclose to each other any subsequently known statutory bar that occurs for an invention disclosed but for which a patent application has not been filed. All invention disclosures shall be marked as confidential under 35 USC 205.

ARTICLE XV. TITLE TO INVENTIONS

A. Whereas Contractor represents that the DOE has granted rights to Subject Inventions under this CRADA, each Party shall have the first option to retain title to any Subject Invention made by its employees. A Subject Invention will be owned as follows:

1. If made solely by personnel of a Party, it shall be the property of that Party ("Inventing Party"). The Inventing Party shall provide to the other Party a license in accordance with the attached Appendix C.
2. If made by personnel of both Parties, it and all patent applications filed therefore and all patents issued thereon shall be jointly owned by the parties and available for use and licensing without obligation to account to the other Party, subject to the obligations contained in Articles VII and VIII.

B. The parties acknowledge that the DOE may obtain title to each and every Subject Invention reported under Article XIV for which a patent application or applications are not filed and for which any issued patents are not maintained by any Party to this CRADA, subject to retention by the participant of a nonexclusive, nontransferable, irrevocable, worldwide, paid up license with the right to sublicense without accounting to the DOE.

C. The Parties acknowledge that the Government retains a nonexclusive, nontransferable, irrevocable, paid up license to practice or to have practiced for or on behalf of the United States every Subject Invention throughout the world. Contractor represents that the Government has agreed that such use shall be for government use only and not for commercial purposes.

ARTICLE XVI. FILING PATENT APPLICATIONS

A. The Parties agree that the Party initially indicated as having an ownership interest in any inventions shall have the first opportunity to file U.S. and foreign patent applications; but if such Party does not file such applications within six months after disclosure, then the other Party to this CRADA may file patent applications on such inventions. The Parties shall agree among themselves as to who will file patent applications on any joint invention. If a patent application is filed by the other Party ("Filing Party"), the Inventing Party shall reasonably cooperate and assist the Filing Party, at the Filing Party's expense, in executing a written assignment of the Subject Invention to the Filing Party and in otherwise perfecting the patent application, and the Filing Party shall have the right to control the prosecution of the patent application.

B. The Parties agree that if neither Party desires to file a patent application for any invention, notification of such negative intent shall be made in writing to the cognizant DOE patent attorney within nine (9) months after the initial disclosure of such invention or not later than 60 days prior to the time when any statutory bar might foreclose filing of any patent application.

C. A Party electing title or filing a patent application in the United States or in any foreign country shall advise the other Party and the DOE if it no longer desires to continue prosecution or retain title in the United States or any foreign country. The other Party and then the DOE will be afforded the opportunity to take title and retain the patent rights in any such foreign country.

D. Each Party agrees to provide the Project Manager of the other Party with a copy of each patent application it files on any Subject Invention.

E. Every three months from the date of the CRADA, each Party shall deliver to the other Party interim reports listing the Subject Inventions, if any, it has produced during the preceding three-month period. If a Party has produced no Subject Invention for any three-month period, the Party's interim report for that period will explicitly state so.

ARTICLE XVII. COST OF INTELLECTUAL PROPERTY PROTECTION

Each party shall be responsible for payment of all costs relating to copyright filing, U.S. and foreign patent application filing and prosecution, and all costs relating to maintenance fees for U.S. and foreign patents hereunder which are owned by that Party.

ARTICLE XVIII. REPORTS OF CRADA TECHNOLOGY USE

For a period of five years after completion of the CRADA, participant agrees to submit, upon request of DOE, a non-proprietary report on efforts to utilize technology arising under the CRADA.

ARTICLE XIX. DOE MARCH-IN RIGHTS

The Parties recognize that the DOE has certain march-in rights to Subject Inventions in accordance with 48 CFR 27.304-1(G).

ARTICLE XX. U.S. COMPETITIVENESS

Participant agrees that all research and development under this CRADA shall be conducted in U.S.-based facilities. Participant further agrees that for a period of 2 years following the CRADA subsequent research and development by the Participant for the purpose of commercializing technologies arising from this CRADA, which are the primary focus of this CRADA, shall be performed substantially in U.S.-based facilities.

ARTICLE XXI. ASSIGNMENT OF PERSONNEL

A. It is contemplated that each Party may assign personnel to the other Party's facility as part of this CRADA. Such personnel assigned by the assigning party, to participate in or observe the research to be performed under this CRADA shall not, during the period of such assignments, be considered employees of the receiving Party for any purposes.

B. The assigning party's employees and agents shall observe the working hours, security and safety rules, and holiday schedule of the receiving Party while working on the receiving Party's premises. Receiving Party shall have the reasonable right to approve the assignment of personnel or request their removal by the assigning Party.

C. The assigning Party shall bear any and all costs and expenses with regard to its personnel assigned to the receiving party's facilities under this CRADA. The receiving Party shall bear facility costs of such assignments.

ARTICLE XXII. FORCE MAJEURE

No failure or omission by Contractor or Participant in the performance of any obligation under this CRADA shall be deemed a breach of this CRADA or create any liability if the same shall arise from any cause or causes beyond the control of Contractor or Participant, including but not limited to the following, which, for the purpose of this CRADA, shall be regarded as beyond the control of the Party in question: Acts of God, acts or omissions of any government or agency thereof, compliance with requirements, rules regulations, or orders of any governmental authority or any office, department, agency, or instrumentality thereof, fire, storm, flood, earthquake, accident, acts of the public enemy, war, rebellion, insurrection, riot, sabotage, invasion, quarantine, restriction, transportation embargoes, or failures or delays in transportation. The contractual acts of the DOE as a party to the separate contract with the Contractor shall not automatically excuse the Contractor's performance under the CRADA; and in such case, Contractor's rights and obligations would be governed by the terms and conditions of this CRADA.

ARTICLE XXIII. ADMINISTRATION OF THE CRADA

It is understood and agreed that this CRADA is entered into by the Contractor under the authority of its prime Contract with DOE. The Contractor is authorized to and will administer this CRADA in all respects unless otherwise specifically provided for herein. Administration of this CRADA may be transferred from the Contractor to DOE or its designee as a successor to Contractor who is assuming responsibilities for the facilities managed by Contractor with notice of such transfer to the participant, and the Contractor shall have no further responsibilities except for the confidentiality, use and/or non-disclosure obligations of this CRADA. This CRADA shall be binding upon and inure to the benefit of the parties, and their respective successors and assigns.

ARTICLE XXIV. RECORDS AND ACCOUNTING SYSTEM

The participant shall maintain records of the following with respect to all government property in its custody, related to the CRADA: receipts, expenditures, and dispositions. Participant represents that its accounting system is in accordance with generally accepted accounting principles.

ARTICLE XXV. NOTICES

A. Any communications required by this CRADA, if given by postage prepaid first class U.S. Mail addressed to the party to receive the communication, shall be deemed made as of the day of receipt of such communication by the addressee, or on the date given if by verified facsimile. Address changes shall be given in accordance with this Article and shall be effective thereafter. All such communications, to be considered effective, shall include the number of this CRADA.

B. The addresses, telephone numbers and facsimile numbers for the Parties are as follows:

CONTRACTOR

PARTICIPANT

ARTICLE XXVI. DISPUTES

The Parties shall attempt to jointly resolve all disputes arising from this CRADA. If the parties are unable to jointly resolve dispute within a reasonable period of time, they agree to follow the dispute resolution process set forth in Appendix F. To the extent that there is no applicable U.S. Federal law, this CRADA and performance thereunder shall be governed by the law of the state of _____, without reference to that state's conflict of laws provisions.

ARTICLE XXVII. ENTIRE CRADA AND MODIFICATIONS

A. It is expressly understood and agreed that this CRADA with its Appendices, which are attached hereto and incorporated herein by reference, contains the entire agreement between the Parties with respect to the subject matter hereof and that all prior representations or agreements relating hereto have been merged into this document and are thus superseded in totality by this CRADA. This CRADA shall not be effective until approved by DOE and the effective date shall be the date when signed by the last of the Parties.

ARTICLE XXVIII. TERMINATION

This CRADA may be terminated by either Party upon 30 days written notice to the other Party. In the event of termination by either Party, each Party shall be responsible for its share of the costs incurred through the effective date of termination, as well as its share of the costs incurred after the effective date of termination, and which are related to the termination. The confidentiality, use, and/or non-disclosure rights and obligations of this CRADA shall survive any termination of this CRADA.

ARTICLE XXIX. PROJECT MANAGEMENT

A. Each Party shall assign and identify in writing a Project Manager prior to the start of the CRADA. Either Party may change its Project Manager by providing written notification to the other. Each Project manager shall be responsible for coordinating all matters relating to this CRADA, any Statement of Work hereunder, and all other related matters between the Parties. All communications between the Parties relating to this CRADA shall take place between the Project Managers.

B. Project Managers for this CRADA are as follows:

For Contractor

For Participant

C. The Parties will use reasonable efforts to manage the disclosure of Proprietary Information or Protected CRADA Information through the Project Managers or their designees; however, failure to do so will not cause any marked Proprietary Information or any marked Protected CRADA Information to lose the protection afforded by Articles VII and VIII.

FOR CONTRACTOR:

FOR PARTICIPANT:

BY _____

BY _____

TITLE _____

TITLE _____

DATE _____

DATE _____

This Page Left Intentionally Blank

APPENDIX E

FACILITATOR APPROACH TO CRADA SUCCESS

(How Can a CRADA be Used by Small Business?)

This Page Left Intentionally Blank

FACILITATOR APPROACH TO CRADA SUCCESS

**How Can a CRADA be
Used by Small Business?**

R. L. Webb
September 1993

IG Technologies
Gateway Technologies International, Inc.

Needs

- Assess Industry R&D Needs
- Match With DoE Technology Catalog
- Develop Model for a Successful CRADA

PROBLEM:

No simple mechanism exists to transfer DoE HPCC technology to industry.

Industry Examples

Publishing

Entertainment

Shipbuilding

Food Packaging/Processing

Construction/A&E

Banking

Advertising

DoE Examples

Nuclear Weapons

IANWD

LLNWD

Radiation Hardening

CRADA

BENEFITS TO INDUSTRY

- Lowers R&D Cost
- Provides faster access to marketplace.
- Can yield greater profits.
- Provides synergism (or a path) to create access to new markets/customers.
- Creates a new level of cooperation and communication between government and industry.
- Minimizes investment capital.
- Keeps some key staff available for other tasks (leverage).

HOW CAN CRADAS BE SUCCESSFUL?

- Use an outside small business to aid in T.T. (Create an independent facilitator role to aid in T.T.)
- Make industry managers the Risk Managers.
- Minimize the politics.
- Make DoE the advocate.

BENEFITS TO DOE

- Improved interaction with industry.
- Improve U.S. productivity.
- The U.S. becomes the winner.
- Satisfies Congressional mandates to transfer technology to small business.
- Becomes a potential transition training ground for DoE employees.

ROLES

DOE

Principal Scientist/Engineer

Documentor

Advocate

Shortcutter

SKILL/SPECIALTY

Either invented or played a key role in the technology.

Can develop useable documentation and descriptions of the technology.

Someone in DoE who wants the project to succeed (and has the power to do it).

A can-do person who at top levels can get things done.

ROLES

WHO MUST BE INVOLVED

U.S. INDUSTRY

Commitment Manager

Chief Technical Officer

Risk Manager

Production Engineer

SKILLS/SPECIALTY

The person in the company willing to give up profit dollars to achieve new levels of competitiveness.

The person in the company responsible for technical direction of the company.

The person who will minimize risk to the company.

The person who will have to live with the technology center.

**RISK MODELING
AS A SERVICE
OF THE
FACILITATOR**

- Use accepted risk assessment technique models.
- Identify major roadblocks prior to CRADA.
- Assess organizational/political/technical risks/impediments to success.
- Develop T.T. management plan around risk mitigation plan.

POTENTIAL PITFALLS AND PROBLEMS OF PERFORMING A CRADA

PROBLEMS

- A CRADA diverts resources, and may cause a small company to lose focus.
- A CRADA could become a bottleneck to progress if risks are not understood apriori.
- Incorporating CRADA technology involves a learning curve and thus costs may go up. You do not have complete control. Thus, delays may ensue.
- Many small companies are not accustomed to formalizing their R&D. This must be done under a CRADA. This creates a new cost.
- Most R&D for U.S. industry is designed to make a profit. None of DoE's R&D efforts were designed to make a profit. A balance between defense and commercial motivation is needed.
- Software: Much DoE software was designed without regard to maintenance or commercial application. It may not be worth the trouble.
- Hardware: Many projects will be quite advanced yet still require huge investments to be usable by industry. A multiplier of 10:1 for commercialization may be common.

SOLUTIONS

- DoE should be prepared to spend many more resources (\$) than industry to make the process work. (Maybe 7 to 1.)
- Industry must share its risks and rewards to the people able to make the transfer successful by being able to offer jobs to government personnel after CRADA is completed intern process.
- DoE must be prepared to lose its best people to industry.
- A process of selecting winners must be developed which makes the big risk taker the winner.
- Private capital must be allowed to dictate terms of the CRADA.
- Industry must have management direction to achieve their goals. DoE cannot simply offer a supermarket approach to T.T.
- DoE employees must relinquish their technologies more freely. They cannot guard them as if they were their personal property.
- Let industry be the leader.
- Utilize a facilitator - DoE funded.

**THE ROLE OF FACILITATOR
FOR
COOPERATIVE RESearch AND DEVELOPMENT AGREEMENTS
(CRADA)**

- Identify DoE capabilities for HPCC/Tech Transfer.
- Survey industry needs to find participants for DoE CRADAs.
- Act as "Technology Broker" to aid in motivating small/medium companies to participate in the CRADA process.
- Assist in providing key support to DoE to ensure end results have a positive industrial impact.
- Find the most cost-effective means to transfer HPCC capabilities to industry.
- Safeguard industry and DoE interests.

RECEIVED

NOV 01 1994

OSTI