THE TRANSFER OF ACCELERATOR TECHNOLOGY TO INDUSTRY

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The national laboratories and universities are sources for innovative accelerator technology developments. With the growing application of accelerators in such fields as semiconductor manufacturing, medical, therapy isotope production, nuclear waste transmutation, materials testing, bomb detection, pure science etc., it is becoming more important to transfer these technologies and build an accelerator industrial base. In this talk the methods of technology transfer, the issues involved in working with the labs and examples of successful technology transfers will be discussed.

Introduction

During the past 50 years there has been an explosion in the use of particle accelerators bringing them into almost everyone's home in the form of television and computer screens. The second largest use being for medical diagnostic and industrial x-rays. Most people do not even realize these devices are accelerators. This proliferation has continued over the past decade and will continue with the growing application of accelerators in such fields as basic sciences, medical therapy and diagnostics, semiconductor manufacture, detection of contraband materials, nuclear waste transmutation etc. This next level of growth will probably not see such large numbers of devices however their size and complexity will be much greater. National Laboratories and universities in many nations are the repositories of innovative accelerator technologies. In order to build an industrial base to meet the needs of this growing field emphasis must be placed on technology transfer not only in the United States but everywhere. In this talk I will discuss the various methods of technology transfer, present some successful examples and discuss issues and concerns involved in such transfers.

The Resource

In the U.S. and elsewhere I believe the national labs and the universities are a national treasure, for example in the U.S. for the Department of Energy we have the following figures:

- $6B Annual R& D Expenditure
- 30 R&D Laboratories
- 35,000 Scientist and Engineers
- 14,000 Trained Technicians

If one adds the labs of other organizations, universities, etc. and other funding organizations such as the National Science Foundation, the Department of Defense, National Institute of Health, etc. these already impressive numbers become even larger. Similar situations exist in Europe, Japan and Russia.

Mechanisms of Technology Transfer

There are many methods by which technology is transferred to industry for example:

- The transfer of people
- Industry/Laboratory Collaboration
- Industry/Laboratory Personnel Exchanges
- Contracts and Procurement
- Individual Consulting
- Modest Requests for Technology
- Patent and Copyright Licensing
- Work for Others

All of the above mechanisms provide various degrees of technology transfer some being more satisfactory than others. I would now like to discuss each of these in more detail giving examples where possible of successful technology transfer.

The Transfer of People There are many examples of the transfer of people from laboratories to industry. LeCroy Corporation and AccSys Technology Inc. are two that I am familiar with. LeCroy, one of the leaders in fast electronics for accelerator experiments, with offices in the U.S. and Europe, was formed when Walter LeCroy, present CEO, left Columbia University's Nevis Laboratory to start his own business taking with him the technological skills he had acquired there. Walter has stated that "The transfer of people is probably the most effective means of technology transfer". LeCroy Corporation which was formed about 28 years ago is now about $60 million a year in sales. AccSys Technology Inc. a much younger corporation formed in the 1980's was founded by Bob Hamm when he and several colleagues left Los Alamos National Laboratory to start their business. Today with annual sales of $3.3 million they are producing linear accelerator components i.e. radio frequency quadrupoles, drift tube linacs, RF power supplies and ion source systems. It should be noted that once the transfer of people has taken place further technology transfer is usually implemented by the other mechanisms listed above.

Industry/Laboratory Collaboration This category covers situations where a laboratory and an industry decide, for their mutual benefit, to collaborate on a technology development. In these cases there are no exchange of funds i.e. each uses their own R&D funds to support the work. there are several mechanisms by which this process can proceed from a handshake to what is called a CRADA. Now since CRADA's are becoming so important in the U.S. I will give a brief description. CRADA stands for

Cooperative Research and Development Agreement. The National Competitiveness Technology Transfer Act (NCTTA PL101-189) that was signed into law in November 1989 enables all U.S. government R&D laboratories to negotiate and enter into CRADA's with businesses and non-federal entities. CRADA's provide opportunities to leverage manpower, facilities, and financial resources while carrying out a project of mutual interest. These agreements include addressing who will own the rights to any intellectual property (patent or copyright) created and the protection of proprietary information brought to the project or created during the project. This act explicitly made technology transfer a mission of all U.S. government laboratories requiring the governing agencies DOE etc. to incorporate that mission into the laboratory contracts with the legal entity responsible for operating the laboratory. It also extends protection from Freedom of Information Acts requests for CRADA's.

Now I will discuss two examples of Laboratory/Industry collaborations which involve my own company Grumman Both of these programs which began with hand shake agreements are now being structured into CRADA's. First, two years ago we began a collaboration with Brookhaven National Laboratory (BNL) on the development of a "High Brightness, High Duty Factor RF Gun". This work was reported on in detail earlier this week at this conference by Ira Lehrman in session TU2. The collaboration involves scientists and engineers at BNL's Accelerator Test Facility directed by Ilan Ben Zvi and their counterparts at both Grumman's Corporate Research Center and Advanced Energy Projects group. This collaboration pooled the resources of both groups for mutual benefit. It helped BNL in developing and fabricating its FEL user facility and it facilitated Grumman in obtaining FEL technology for its future programs. For this program BNL and Grumman jointly performed the RF modeling of the gun, Grumman is assisting BNL in the test and conduct of the experiments and Grumman has done the thermo and mechanical design and fabrication of the gun. This work has now been extended to Grumman's involvement in the superferritic wiggler development for BNL's Harmonic Generation FEL Program. In this effort BNL is responsible for theory and winding of the wiggler and Grumman is responsible for magnetic modeling, design, fabrication and measurement. In addition Grumman is responsible for design and fabrication of the cryostat. I believe I can say that both BNL and Grumman have benefited significantly from this collaboration.

The second program, which started about a year ago, is a collaboration with Los Alamos National Laboratory in the area of "Accelerator Transmutation of Waste", ATW. Stan Schriber mentioned this program earlier this week in his talk during session M02 "Accelerator for Spallation Sources". This collaboration involves scientists and engineers at both LANL's Accelerator Technology Division and their Nuclear Power Division. Grumman is supporting LANL in two areas namely: 1) in the development of a cost model of ATW both for military nuclear waste and nuclear waste from commercial reactors, 2) accelerator technology areas such as improving RF efficiency of cavities and other RF structures and in the development of reliable CW ion sources. This latter effort, the CW ion source work builds on another technology transfer effort with Dr. K. Leung of the Lawrence Berkeley Laboratory, LBL. Grumman has been working with LBL using several of the tech transfer mechanism such as consulting and procurement. The primary area of Grumman contribution is the measurement of beam output characteristics and automation of ion source operation. To date the collaboration with LANL is proceeding very well for both parties.

Industry/Laboratory Personnel Exchanges Again there are various options with this method such as an industry representative spending a year or so at a laboratory at company expense or at laboratory expense and vice versa. I will now give an example of both directions of personnel exchange.

In 1985 Grumman arranged to place Joe Bundy one of its space structural designers at LANL to support the Beam Aboard Rocket Experiment, BEAR. Mr. Bundy spent two years at LANL sponsored by Grumman, helping LANL design the structures for the BEAR accelerator package. LANL benefited from our space technology, and we benefited by learning some of the accelerator technology which lead to our designing and fabricating the BEAR RFQ accelerator.

At the end of 1990 the Brobeck Project Manager for the Louisiana State University 1.4 GEV synchrotron called Rolland Johnson of Fermi National Accelerator Laboratory requesting his help on the accelerator control system. Brobeck had won a contract to build a 1.4 GEV synchrotron at the University, they knew how to build the machine but needed help in how to run it. Johnson was hired by Brobeck to help design the control system but remained a Fermi employee.

Contracts and Procurement "The good, old-fashioned way" as Dick Carrigan of Fermilab likes to say. The options here again are many. They vary from build-to-print and purchase of off-the-shelf items to industrial partnerships and large scale government procurements involving training. Obviously the degree of technology transfer differs considerably depending on the option. From a technology transfer point of view procurement of off-the-shelf items an build-to-print are the least satisfactory albeit very important to the financial health of industry. For industry to grow and compete in the accelerator business it must participate in the intellectual developments.

The procurement of the superconducting magnets for the Superconducting Super Collider, SSC, in Texas and the Relativistic Heavy Ion Collider, RHIC, at BNL are excellent examples of technology transfer. For years prior to the actual Request for Proposals, RFP's, on these projects companies such as General Dynamics, Westinghouse, Babcock and Wilcox and Grumman interacted with the national labs to different degrees. Some placed personnel at the labs, some worked on small contracts and some did both. After the award for the SSC dipoles General Dynamics worked with Fermilab and Westinghouse with BNL helping them build a series of dipole magnets thereby learning first hand the technology involved. Similar activities are now being undertaken by Babcock & Wilcox on the SSC quadrupoles and Grumman on the RHIC dipoles. After the training period these companies will undoubtedly make changes in the tooling and other procedures for the purpose of high rate production. In the end having these partnerships will result in the growth of a superconducting magnet industry in the U.S. Prior to these projects there were no U.S. companies with superconducting dipole magnet experience only Japanese and European.

One of the most successful tech transfer projects that I am familiar with is Grumman's industrial partnership with LANL on the Ground Test Accelerator, GTA. For the past 5 years about 25 Grumman scientists and engineers have been integrated into the LANL GTA project at the Los Alamos facility. Almost every technology area has Grumman participation including the project management. Each month one or more Grumman personnel return to Grumman's Bethpage facility to lecture their fellow coworkers on their efforts thereby bringing the technology back to the company providing leverage in the learning processes. The GTA project is a highly successful technology transfer project.

Procurements from the laboratory to industry both labor and computer code developments are another excellent avenue for tech transfer. Laboratories such as LANL are continually developing physics codes and refining them. These codes are necessary for the physics designs of new accelerators. At Grumman we have purchased these codes from LANL and others and also subcontracted with the labs for initial support in utilizing such codes. Recently Lloyd Young of LANL spent several weeks at Grumman aiding us in low power testing of the CWDD RFQ utilizing his new software. We will purchase this new software when it becomes available.

An important program for technology transfer in my company's evolution in the accelerator industry was our subcontract to design and fabricate the BEAR RFQ for LANL. LANL was responsible for the physics design of the RFQ and LANL and Grumman together performed the design. Grumman's major contribution was in the concept of the electroformed design and the special tooling for tuning and forming. Grumman had total responsibility for the fabrication utilizing the machining tapes from LANL but even here LANL experience was utilized in the machining of the vanes.

Grumman participated in the tuning and low power RF testing. Via the transfer of computer codes and aid in helping us build bead-pull apparatus Grumman is now capable of doing RF cavity testing on its own in fact we recently tested a RFQ for the Physics Department at Stony Brook University. This surely is a tribute to LANL tech transfer to Grumman.

<u>Individual Consulting</u> Most companies independent of size utilize consultants from the labs and universities. Consultants are used to bolster a area of technology weakness especially on entering new fields. Companies can not afford to have experts in every field on their staffs full time. My first interaction with a consultant was in the late 1950's when I had built a duoplasmatron ion source for some experiments I was conducting on micrometeorite impacts. I used a paper written by Charlie Moak from Oak Ridge National Laboratory (ORNL) for the design. Try as I did I could not obtain the currents he claimed in his paper. I called Moak and asked if he would be willing to consult, not only did he agree but he said he felt it was part of the mission of ORNL to help industry. He visited my lab took one look at the drawings and noted that I had not received the errata to his paper, i.e. the extraction annulus had to be modified. He rolled up his sleeves and with the use of a lathe corrected the problem. The next day we operated the source and obtained full current. Now that is a consultant! The lesson to be learned here is get the consultant involved before fabrication.

When Grumman entered the competition to build the CWDD accelerator for the U.S. Army in the late 1980's we had a big hole in the physics area. We had good physicists but their experience in ion sources and linear accelerators was limited. We fixed this deficiency by adding a Physics Advisory Board to our team. We choose a top rate team of accelerator experts namely John Stables from LBL, John Farrell and Dick Purser from LANL and Pierre Grand from BNL. I believe this was a significant factor in our being awarded the contract. These consultants did more than advise, they spent time at our facilities overseeing our physics design, checking our results, making recommendations etc. With this help we were able to do the complete physics design of the CWDD accelerator. The technology transfer during the critical design phase was excellent.

<u>Modest Request for Technology</u> The laboratories continually develop technology for use on their own projects in particular in the area of diagnostics, small power supplies and other small items. Two examples of such systems that we now have at Grumman include a bead pull apparatus for tuning cavities and taught wire system for magnetic alignment of drift tubes. Though these are excellent examples of technology transfer, but knowledge of their existence is not always widespread.

<u>Work for Others</u> The best example I know in this area is the program Fermilab conducted for Loma Linda Hospital. Loma Linda wished to establish a proton therapy facility at their California location. Fermilab took on the design task and sent out a request for industrial involvement. SAIC was selected and worked with Fermilab to build the machine and test it at Fermilab. SAIC then dismantled the system and reassembled it at Loma Linda. They commissioned the machine and it is now treating patients. I believe SAIC obtained exclusive rights to the Loma Linda design under this agreement. This is another excellent example of technology exchange helping a company establish a new business line.

<u>Issues</u> The major impediments to technology exchange are the cultural differences between lab and industrial personnel. No law by itself will bring about technology

transfer. The lab directors must be strong supporters and they must convey their feelings to all the lab personnel. Of the lab directors that I know personally all are strongly behind technology transfer. Acceptance by the laboratory personnel is mandatory for success. To accomplish this there must be a mutual interest in the project, mutual trust must be established and the concept must not threaten the job security of the lab personnel. There must be an understanding of the cultural differences for example: profit motive vs. recognition for technical achievement, proprietary rights vs. compulsion to publish, achieving adherence to schedule vs. we can make it better or perfection is the enemy of good enough.

Cultural differences exist even in the approach to a program, for example at the labs an idea is generated one looks to do a proof of principle and then test a prototype. Industry when confronted with a new idea first must confirm the existence of a market, then it sets specifications for the concept to meet this new market and then and only then will it implement production plans.

Recommendations

To implement technology transfer and support economic growth in their nations, I believe government funded laboratories should adhere to the following:

- Laboratories should cooperate with industry not compete
- Laboratory involvement on applied projects
  - — Generate the idea
  - — Conduct ground work - feasibility studies
  - — If concept looks appealing make announcement to industry
  - — Form CRADA's with interested industries
  - — Promote and conduct conceptual design studies and technology developments
  - — Involve industry in conceptual design studies
  - — Design and fabricate prototype of system
  - — Involve industry in the prototype
  - — Turn over prime role to industry after the prototype
  - — Support industry in all phases after the prototype

Now as in every system it becomes important to establish balance. With regard to technology transfer from the labs and universities it is important that a balance be established between tech transfer projects and long term R&D. If the pendulum swings too far in the tech transfer direction we run the risk of depleting the treasure represented by these institutions. We in industry should be advocates of healthy R&D programs at the labs and universities. The lab directors; their administrations, the controlling government agencies and the U.S. congress should never lose sight of the value of R&D. Another way of saying this is lets farm the eggs not kill the goose.

Conclusions

I can say without qualifications that Grumman's position in the accelerator industry today is due to its many technology transfer projects with national labs such as LANL, BNL and LBL. Scientists and engineers at these facilities provided us with the knowledge and tools necessary for our future growth in the accelerator industry.