DRAFT

The July 28, 1987 press release on the President's Superconductivity Initiative indicates among its primary objectives:

Better protecting intellectual property rights of scientists, engineers and businessmen working in superconductivity.

Implementation of Executive Order 12591 which is designed to: (1) transfer technology developed in Federal laboratories into the private sector; and (2) encourage Federal, university and industry cooperation in research.

Title IV of the proposed bill does not fully address these objectives. The Title does not resolve the problem of whether Federal laboratories and contractors have the right (even if agreed to by a Federal agency) to establish intellectual property rights in the form of copyrights or trade secrets to protect technology generated with Federal funds. It is clearly the intent of E.O. 12591 as indicated by Section 1.(b)(1)(B) and (b)(6) to resolve this in favor of permitting laboratories and contractors to establish such rights. It is our view this problem must be addressed because current laws such as P.L. 98-577 and P.L. 98-525 have been interpreted by some as precluding ownership of intellectual property rights to technical data and computer software by contractors. Further, current law precludes copyrighting the technical data and computer software made by government-employees (see 17 U.S.C. 105). Additionally, it is currently unclear whether Federal contractors, even if given ownership of technical data or computer software, would be able to maintain such items in confidence if the items were in the possession of a Federal agency because of the agency's obligation to release under FOIA. Title IV addresses this last issue only in the context of Federal laboratories but not in terms of Federal contractors who have delivered technical data or computer software to a Federal agency.

Given title IV's failure to address these fundamental problems we do not view it possible to meet the primary objectives of the superconductivity initiative. Certainly in some instances the private sector without the guarantee of clear intellectual property protection will be unable or unwilling to pursue commercialization of federally-funded technology which is in early stages of development.

In light of the above, we offer the attached substitute for title IV. This substitute is intended to establish for the first time the right in the Executive Branch, notwithstanding any other law, to allow its agency laboratories and contractors to establish intellectual property protection in technical data or computer software generated with federal funding. Further, if this protection takes the form of holding technical data or computer software in confidence, laboratories and contractors' rights are protected from release of the technical data or computer software by exempting agencies from disclosure of such items under FOIA.

We are attaching as a matter of information an article on the Japanese initiative to manage technology generated by Japanese Government funding. It should be noted that the Japanese have the authority to maintain and transfer such technology in confidence.

TITLE IV - MANAGEMENT OF FEDERALLY FUNDED TECHNICAL DATA AND COMPUTER SOFTWARE

SEC. 401. <u>Retention of Intellectual Property Rights</u>

Notwithstanding any other provision of law -

(1) Each federal agency may permit federal contractors to retain ownership to any intellectual property rights that can be established to protect technical data or computer software generated under a federal contract in exchange for a license to meet agency needs.

(2) Each federal agency may grant the director of any of its government-operated laboratories the authority to retain ownership rights to technical data or computer software developed at the sole expense of the laboratory or jointly under a cooperative research and development agreement by establishing intellectual property protection, which may be assigned or licensed separately or granted in advance in connection with a cooperative research and development agreement.

SEC. 402. <u>Disclosure of Technical Data and Computer Software</u>

(a) Technical data or computer software obtained or generated by a federal agency under a contract shall not be disclosed to the public if -

(1) the head of the agency or his or her designee determines, at the time the contract is entered into, that -

(A) there is a reasonable expectation that technical data or computer software which may be obtained or generated under the contract may be commercially valuable; and

(B) disclosure of such technical data or computer software could reasonably be expected to cause substantial harm to the proprietary interests of the contractor; and

(2) such contract provides that technical data or computer software obtained or generated by the agency under such contract shall not be disclosed to the public.

(b) Technical data or computer software developed at a laboratory by the federal government shall not be disclosed to the public if the head of the agency which operates the laboratory or his or her designee determines that -

(1) the technical data or computer software is commercially valuable; and

(2) there is a reasonable expectation that disclosure of the technical data or computer software could cause substantial harm to the commercial application of such information.

(c) Technical data or computer software obtained or generated by a federal agency under a cooperative research and development agreement shall not be disclosed to the public if -

(1) the head of the agency or his or her designee determines, at the time the cooperative research and development agreement is entered into, that:

(A) there is a reasonable expectation that technical data or computer software which may be obtained or generated under the cooperative research and development agreement may be commercially valuable; and

(B) disclosure of such technical data or computer software could reasonably be expected to cause substantial harm to the proprietary interests of the non-federal party which enters into the cooperative research and development agreement; and

(2) such cooperative research and development agreement provides that technical data or computer software obtained or generated by the agency pursuant to such cooperative research and development agreement shall not be disclosed to the public.

SEC. 403. Definitions

As used in this title -

(1) The term "federal agency" means any executive agency as defined in section 105 of title 5, United States Code, and the military departments as defined by section 102 of title 5, United States Code.

(2) The term "contract" means any contract, grant, or cooperative agreement as those terms are used in sections 6303, 6304, and 6305 of title 31, United States Code, entered into between any federal agency and any contractor for the performance of experimental, developmental, or research work funded in whole or in part by the federal government. Such term includes any assignment, substitution of parties, or subcontract of any type entered into for the performance of experimental, developmental, or research work under a contract as herein defined.

(3) The term "cooperative research and development agreement" means any agreement as defined in section 11(d)(1) of title 15, United States Code.

(4) The term "technical data" means recorded information of a scientific or technical nature regardless of form or the media on which it may be recorded.

(5) The term "computer software" means recorded information regardless of form or the media on which it may be recorded comprising computer programs or documentation thereof.

(6) The term "intellectual property" means trademarks, copyrights, trade secrets or the protection of semiconductor chip products, but for purposes of this title does not include patents.

(7) The term "laboratory" is as defined in section 11(d)(2) of title 15, United States Code.

SEC. 404. <u>Regulations</u>

The Office of Federal procurement Policy, in cooperation with the affected federal agencies, may issue regulations which may be made applicable to the federal agencies implementing sections 401 through 403 of this title and shall establish a standard contract provision to implement such sections.

SEC. 405. <u>Effective Date</u>

This title shall take effect on the date of enactment.

Section-by-Section Analysis

Section 401(a) - Establishes the authority in each federal agency to allow federal contractors to establish intellectual property protection in technical data or computer software generated with federal funding. This implements, in law, the intent of section 1(b)(6) of Executive Order 12591. Pursuing legal authority is considered appropriate because current laws such as P.L. 98-577 and P.L. 98-525 have been interpreted by some as precluding ownership of intellectual property rights to technical data and computer software by contractors.

Section 401(b) - Establishes the authority in directors of federal laboratories, if delegated by their agencies, to establish intellectual property protection in technical data or computer software generated with federal funding. This implements, in law, the intent of section 1(b)(1)(B) of Executive Order 12591. Pursuing legal authority here is considered necessary in light of the 17 U.S.C. 105 prohibition on creating copyright protection in publications made by federal employees. Further, the law is presently unclear whether the directors of federal laboratories can create a transferrable property right by holding technical data or computer software in confidence.

Section 402(a) - Exempts technical data or computer software to be delivered under contract to a federal agency from disclosure under FOIA if the head of the agency or his designee determines at the time the contract is entered into that the criteria of the section is met.

Section 402(b) - Exempts technical data or computer software developed at a laboratory by the federal government from disclosure under FOIA, if the head of the agency which operates the laboratory or his designee determines that the criteria of the section has been met.

Section 402(c) - Exempts technical data or computer software, which may be obtained or developed under a cooperative research and development agreement, from disclosure under FOIA if the head of the agency or his designee determines at the time the cooperative research and development agreement is entered into that the criteria of the section has been met.

Section 403 - Defines the terms federal agency, contract, cooperative research and development agreement, technical data, computer software, intellectual property, and laboratory.

Section 404 - Provides that the Office of Federal Procurement Policy (OFPP), in cooperation with the federal agencies, may issue regulations which may be made applicable to the federal agencies implementing sections 401 through 403 and establish a standard contract provision to implement such sections. This section is not intended to create any regulatory authority in OFPP over cooperative research and development agreements.

Section 405 - Provides that the title shall take effect on date of enactment.

EAGLE RESEARCH GROUP, INC.

1925 NORTH LYNN STREET • ARLINGTON, VA. 22209 • (703) 522-4040

File w/ Articles

TECHNOLOGY TRANSFER WITHIN THE SEMICONDUCTOR INDUSTRY

Prepared for

Scientific Officer
Office of Naval Technology, OCNR 224
ATTN: James A. Cauffman
800 North Quincy Street
Arlington, VA 22217-5000

Under Contract N00014-85-C-0882

Contract Amount: $302,870.00

Contract was competitively awarded

ERG 87-177M12 April 29, 1987

AUTHORIZATION

This report was prepared by Cormac P. Walsh under contract N00014-85-C-0882, sponsored by the Office of Naval Technology. The views and opinions expressed herein are not necessarily those of the United States Government or the sponsoring agency.

Submitted by
Cormac P. Walsh
President

FOREWORD

Due to the short time permitted for preparation of this paper, references and citations were not given except where essential. The knowledgeable reader will in most instances be able to supply the others. Exact titles were also not checked, and acronyms and jargon generally understood in the industry were used without further explanation. Many groups and organizations that should have been included were not, and deserve apologies for omission. Apologies are also in order for the coarse, unedited nature of the text.

TECHNOLOGY TRANSFER WITHIN THE SEMICONDUCTOR INDUSTRY

I. INTRODUCTION

This paper is a companion to ERG 87-177M11, "Technology Transfer from University to Industry in the Semiconductor Industry," 24 April 1987, which examined the efficacy of technology transfer from academia to U.S. industry and the vulnerability of that technology in an international competitive environment. It concluded that such technology transfer was proceeding successfully, despite some negative perceptions, particularly through "centers" at major universities. The technology protection issue developed into one of long term enhancement of foreign industrial infrastructure through the repatriation of U.S. educated students.

This paper is more general in scope, and examines technology transfer within the industry, both intra- and international. It looks again at technology protection, once more in terms of international competitiveness and not national security.

II. BACKGROUND

In an industry where product lifetimes are measured in terms of several years and where lead times of less than a year are competitively significant, one is drawn to examine only highly effective technology transfer mechanisms when studying competitiveness. To be sure, long term transfers and effects should be included in estimating the future make-up of the industry and prospects for future competitiveness, but that is a much larger study, well beyond the scope of the present, modest effort.

Previous efforts to identify and rank order technology transfer mechanisms produced some initially surprising, although in the end intuitively satisfying results. It appeared possible to identify close to twenty distinguishable transfer mechanisms that could be generally accepted as covering all those of interest. It was also possible to loosely rank order these mechanisms by their effectiveness, again with general acceptance. By loosely ranked is meant that there was not universal agreement that neighboring entries were necessarily in the right order but that, as a whole, the top entries were indeed the most effective, the next group less so, and so on. The adequacy of loose ranking was demonstrated by an exercise in which quantitative ratings of effectiveness were assigned to each transfer mechanism. The results showed a bimodal distribution, as shown in Figure 1.

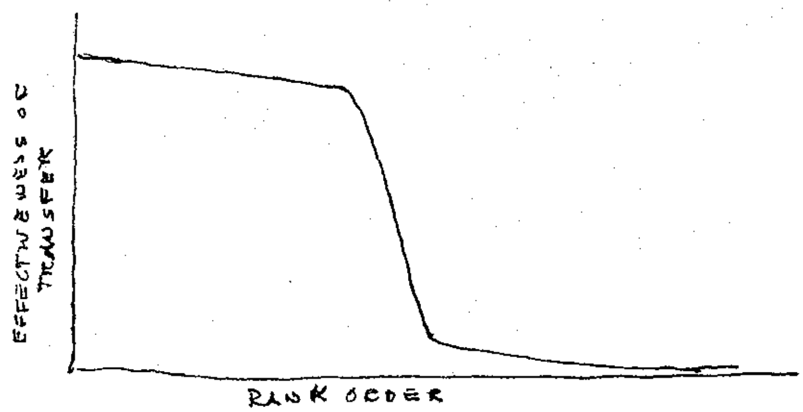

Fig. 1. Effectiveness of Transfer Mechanisms

The mechanisms broke into two large classes, one highly effective and the other relatively ineffective, and a third, smaller class of varying effectiveness. It is clear that the <u>exact</u> ranking is of little consequence.

The most effective class is characterized by activities that involve both interpersonal interaction and hardware and physical activities; cooperative developments, on-site troubleshooting, bringing manufacturing equipment on line are examples of these mechanisms. The least effective mechanisms involved communications and modest interpersonal relations, such as seminars, plant visits, shows, exhibits, casual technical discussions, etc. Finally, the intermediate class seemed composed mostly of providing hardware without people or people without hardware. It includes such disparate activities as intense interpersonal interaction on the one hand and providing equipment at the receiving dock with no set-up or integration assistance on the other.

With this in mind, and considering the short time constants involved in establishing competitive positions, only those mechanisms that are highly effective in promoting active technology transfer need be considered in this analysis. (The definition of "technology" in the previous paper is brought forward here.)

A peculiarity of the semiconductor industry is the "carom" transfer of technology through equipment suppliers. Company A is a supplier of leading edge manufacturing equipment. "A" develops, designs and fabricates its latest model, and tests it to its design specifications. Company B, a semiconductor manufacturer, buys "A's" equipment, and "A" and "B" personnel work to integrate it into the line. Almost invariably the equipment does not perform satisfactorily for "B" and so the companies work together to modify, adapt and test the equipment until "B's" requirements are met. In the process, "A" and "B" interchange their own technology and jointly develop technology. Subsequently, Company C buys Company A's product. Company C receives not only the product and Company A's technology, but Company B's technology and the joint "A" and "B" technology. Thus, in addition to formally traceable technology interchanges through joint ventures, technical agreements and the like, there is an undercurrent of effective technology transfer through the suppliers of design, manufacturing and test equipment. It is not unknown in the industry for semiconductor manufacturers to accept equipment before it is fully satisfactory so that the final modifications and adaptations will remain proprietary.

III. DISCUSSION

A. Design

As in the earlier paper the distinction between "design" and "fabrication" will be retained here. The former includes all of the steps from schematic capture through logic verification, layout, routing, design rule verification, fault checking, circuit simulation to test vector generation and pattern generation tape development. It includes device and process simulation.

"Design" technology is highly software dependent and has been fed extensively by the universities. Competitive lead seems to lie in expansion, modification and updating of programs. Competitive edge is measured in completeness of program packages, ease of use, device complexity accommodated, and processes served. "Design" technology is divided between work station vendors (Daisy, Mentor, etc.), among whom there is fierce competition, and design centers. Some of the latter are independent enterprises that add skilled design consulting to work station availability but many are captive to gate array, semicustom and custom manufacturers. The latter, by providing design assistance, attempt to lock in the designer to a particular product line. They most often proffer assistance and willingness to take over the project at any point in the development.

U.S. companies appear to dominate design technology at present. This is not to say that foreign companies are unable to design, but that U.S. companies are in a strong competitive posture for VLSI, where design unaided by computer is virtually impossible (except for regular physical structures such as memory). There are close to 150 U.S. companies involved in design, from those offering complete systems or services to smaller companies filling niches in linear circuit design, interfaces among other companies' products and other specialty products.

Foreign design appears limited to in-house capabilities and captive design centers, as offered by Fujitsu, Ferranti, Matra, Plessey and Thomson. Specific, product line related design tools are also proffered to work-station vendors. Note that in the case of Thomson the capability was obtained by acquisition of Mostek.

U.S. dominance in "design" to date may be explained by the U.S. origin of the dichotomy (Mead and Conway), by superior software capability, by the relative flexibility of U.S. manufacturers to accommodate profitable Application Specific Integrated Circuit (ASIC) production, by a more protective view of design technology on the part of foreign firms or some combination of all of these. The programs which come out of the universities are solid bases for developing commercial products. U.S. companies appear to be much more adept at building upon these bases than their foreign competitors. Even though U.S. workstations and design centers are made available worldwide, the time and effort required to back out machine code into higher level language for understanding of the programs and simulations is prohibitive, so that the U.S. is likely to maintain its dominance in this arena.

B. Fabrication

Prior to the advent of VLSI, semiconductor products were divided into microprocessors (microcomputers), memory, logic and glue chips, and miscellaneous, the latter including A/D converters, linears, interfaces, etc. Various basic technologies were involved including bipolar (ECL, CML, TTL, etc.) and MOS (p-, n-, CMOS). Consumer electronics accounted for specialty circuits. The U.S. has always maintained its lead in microprocessors and in the miscellaneous category. The Japanese achieved a significant competitive advantage (dumping issues aside) by concentrating on circuit types (memory, logic) that could be fabricated in high-volume, highly automated manufacturing facilities. The Europeans struggled to keep up.

VLSI has begun to change the shape of the industry. The availability of hundreds of thousands of gates on a chip argues

strongly against the notion of "commodity" chips filling standard, widespread need (except, of course, in memory). The ASIC is beginning to replace the logic chips, glue chips and many miscellaneous chips. ASICs include arrays*, semicustom and full custom circuits. ASICs lean heavily on "design" for personalization and customization. This, coupled with the flexibility of U.S. fabrication facilities should represent a significant competitive edge, if explicitly recognized and exploited.

Japanese efforts in ASIC have been hindered by the rigidity and high-volume demands of their fabrication facilities and by U.S. dominance in "design." Their de facto strategy appears to be to concentrate in arrays and to provide, or work with U.S. vendors to develop customizing programs to be included in a workstation's total package.

Arrays have been a godsend for South East Asian developing semiconductor industries. By copying U.S. array product lines in a low labor cost environment, Korean and Taiwanese firms have been able to offer less expensive products while depending on the design capabilities developed to support U.S. product lines.

The Europeans are struggling to keep up.

Each generation of semiconductors sees a migration to greater complexity (gates/chip) and finer critical dimensions. Basic technologies also change, the current trend being to CMOS. The development begins by establishing a baseline process, using the best understanding of current fundamental research. Initial attempts largely show no yield or only partly functional parts. Process and device simulations are used to uncover difficulties and are themselves modified to reflect actual results. One by one yield inhibitors are identified and process solutions found, often by trial and error based on past experiences and technical instinct. In some instances the technology developed precedes the science.

With working parts and some yield the next step is to stabilize the process. This is most readily done by processing and testing, all the while tightening process steps and specifications. Memory is an excellent candidate for this stage of

---

* The term "array" is used here, incorrectly, to generically include gate arrays, programmable logic arrays, programmable logic devices. etc.

development, given the repetitiveness of the basic gates and the physical regularity of layout and interconnection. Problems in physical design, interconnect delays, defects in some circuit elements and not others, etc. do not intrude into the process development. With a stable process, the transition to arrays, semi-custom and custom circuits, as well as to microprocessors, is smooth, since circuit development and process development are not entwined. The use of memory for process development also promises marketable parts, to amortize the development costs early in the product lifetime.

Leaving memory to the Japanese, then, is not only conceding market share but is abandoning the ideal process development tool. Indeed, selling memory below cost (dumping) could be conceived to be part of the cost of development, to be recouped in other parts. Manufacturers should carefully ponder the implications of developing process in memory and meeting Japanese prices, as opposed to process development in complex, random logic.

Viewed in this light the notion of a consortium (e.g., Sematech) to develop the next generation of memory is defective. As a mechanism to recoup memory market share it may have some merit. But, as a process development tool it can only stifle creativity and at best result in a uniform U.S. processing capability. The opportunities of the past to develop different processes (e.g., HCMOS, VMOS, FACT, etc.) would be stifled in an industry-wide consortium. It is interesting to note that the VHSIC contractors have and continue to solve similar process problems in different ways.

IV. TECHNOLOGY TRANSFER AND PROTECTION

Considerations of U.S. semiconductor technology have long been clouded by the myth that industry protects its proprietary technology fiercely, so that there is no cause to worry. The facts do not bear this out. Proprietary protection is only one consideration bearing on the driving U.S. objective: <u>maximize the near-term bottom line</u>. As long as this motivation exists, U.S. industry will part with its technology for instantaneous profit. This is not necessarily a bad strategy if one can be assured of always being one step ahead in technology development and of maintaining market share to support new developments and new products.

The saga of extensive licensing of Japanese industry by Texas Instruments is too well known to be repeated here. Equally disturbing are the numbers of acquisitions, mergers, joint ventures and other alliances, generally predicated on gaining access to U.S. technology in return for market share, that continue to appear. And, the relative mobility of key personnel that characterized U.S. industry is now showing up on the international scene.

Details do not abound, but the following combinations have been reported* as having alliances or joint ventures of some nature.

Motorola-Toshiba	LSI Logic- Toshiba
Motorola-Hitachi	Honeywell-Seiko
AMD-Sony	AT&T-PTT, Spain
Philips-Matsushita	AT&T-Goldstar
Lattice-Seiko	Westinghouse-Mitsubishi
Silicon Systems-Oki	Intel-Fujitsu
LSI Logic-Mitsubishi	

The European expansion seems predicated on acquisition, e.g., Philips-Signetics, Thomson-Mostek as well as exchange agreements. Some reported agreements are:

Siemens-AMD
Siemens-GE
Philips-Intel
Philips-Motorola

The Koreans and Taiwanese are basing their progress on a U.S.-educated skilled manpower pool and the recruitment of U.S. semiconductor engineers, although acquisitions such as Daewoo-Zymos round out the picture.

All in all, then, the international technology picture seems to be one of U.S. companies holding on only to their leading edge technology and trading the rest for market share and bottom line, of European companies trying to buy their way in to technological progress, of Japanese companies competing in technology development, and of Pacific Rim countries carving out their place in commodity markets based on low labor costs and imported technology.

None of this, of course, speaks to the vertically integrated companies, such as IBM, who continue to develop their own technology and supply their own needs. However, cracks are appearing even here, as witness the recent IBM agreements with Intel. Also, not considered again was the semiconductor manufacturing equipment sector which shows an entirely different complex of technologies and competitiveness, but which is deeply involved in technology transfer.

---

* Electronics, 2 April 1987.

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The U.S. semiconductor industry, on the verge of disaster in the commodity parts market, has inadvertently positioned itself to surge forward if it recognizes and exploits its diversity and inherent flexibility. Conceding memory as a process development tool will also concede technological superiority; competitive pricing is required even if losses are ascribed to development cost.

Japan's strengths are in high-volume, automated commodity production. Europeans, primarily vertically integrated, are struggling to keep up through acquisitions and joint ventures. Pacific Rim nations are carving out market share through low cost copying of U.S. and Japanese product lines, while piggy-backing on the U.S. "design" capabilities developed for those lines.

The tangled web of international acquisitions, joint ventures, technology exchange agreements, second-source agreements and other alliances points strongly to lack of concern for technology protection except at the leading edge. U.S. companies appear to be driven by the near-term bottom line, and part with technology for near-term financial reward and market penetration. Japanese companies appear to be intent on dominating market sectors by sequential attacks on market segments. European companies are trying to keep up through acquisitions and technology purchase. Pacific Rim countries are seeking their place by exploiting their unique characteristics (central planning, cheap work force) and importing skilled technologists (repatriated students, U.S. engineers).

Within the industry the Japanese maintain a solid lead in high-volume, highly automated commodity parts production. The U.S. inexplicably retains its lead in microprocessors, microcomputers and digital signal processors. The U.S. has what could amount to an insurmountable lead in ASIC. The major European threat is from acquisitions of U.S. firms, while the Pacific Rim threat is from low-cost copies.

The U.S. industry should take a closer look at itself than it did in arriving at Sematech. The Harvard Business School and Wall Street notwithstanding, an abandonment of the quarterly bottom line mentality may well be in order. Flexibility and diversity will most likely preserve U.S. technology leadership, and should be preserved and nurtured. The great strength of the U.S. in "design" can ensure continued U.S. technological status; it would be a pity if the U.S. evolved into the designer to the world's fabricators.

If government involvement is needed it is in fostering technological development through the memory development phase, through some as yet to be developed strategy that may include severe dumping penalties or even development subsidies.