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Committee to Review the Ohio
Thomas Edison Technology Centers

Commission on Engineering and Technical Systems
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Cover painting of Ohio's industrial diversity by Y. David Chung, 1990

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Committee to Review the Ohio Thomas Edison Technology Centers

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Executive Summary

The committee finds the Edison Technology Centers program to be generally healthy, vigorous, and well managed. The program is valued by Ohio's industrial community and is making a significant and growing contribution to industrial competitiveness in the state.

Each of the nine centers aims to contribute to economic development in Ohio. Beyond having this common purpose, the nine centers are diverse. They differ in their missions, organizations, and target clients because the state has allowed each center to build on unique local resources and needs, and we applaud this approach. Diversity is a strength of the program and has enabled most of the centers to evolve so that their activities are technically sound, cost effective, and perceived to be of value by their user communities.

One result of this diversity is that no set of evaluation criteria can be applied uniformly to all centers. The multiple purposes of the programs, the long periods necessary before some of the activities will significantly augment the state's economic base, and the impossibility of controlled experiments make quantitative evaluation difficult.

The performance of each Edison center should be judged according to how effectively it serves its target community. The centers fall into three broad categories of mission and client relationships:

- existing technologies for smaller, technologically less sophisticated companies,
- state-of-the-art knowledge for larger companies, and
- cutting-edge technologies for creation of new companies and products.

All of these are valid approaches under the Edison center charter, and many centers offer more than one of these activities.

Three centers focus on manufacturing, three focus on materials, two focus on biotechnology, and one focuses on information technology. Six of the centers have successful, active programs and clientele, one has a successful record but is undergoing a promising transition to a new management and broader clientele, one is embarking on a promising restructuring to correct past problems, and the board of directors of one center has decided to cease operations. A summary of each center follows:

- The Edison Polymer Innovation Corporation (EPIC) has a small staff that effectively links two world-class academic polymer programs in Cleveland and Akron with about 80 corporate members for generic research, company-directed research, and problem solving.
- The Edison Materials Technology Center (EMTEC) draws on Wright-Patterson Air Force Base and other Dayton area resources for cooperative research and group problem solving; it has an active, local industrial membership.

- The Edison Welding Institute (EWI), which was formed from the welding research activities and corporate members of three organizations (The Welding Institute's U.S. members, a center at Ohio State University [OSU], and Battelle Memorial Institute), offers training, problem solving, and research at its own and OSU's facilities to member companies from Ohio, the United States, and other countries.
- The Applied Information Technology Research Center (AITRC) invented one product and offered some networking services to small companies; despite a broad-based group of supporters of the center, they never achieved a common vision, and the board of directors has voted to cease operations.
- The Edison Industrial Systems Center (EISC) was created after the University of Toledo surveyed Toledo-area industry to identify broad topics of interest; the center and its four participating academic institutions provide a variety of services for area manufacturing companies.
- The Edison BioTechnology Center (EBTC) is linking small start-up companies in Cleveland with cutting-edge research at local institutions; it aims to use that research to create, nurture, and contribute to the growth of an Ohio-based biotechnology industry.
- The Cleveland Advanced Manufacturing Program (CAMP) has a small administrative staff that links its five component centers (including one of three Advanced Manufacturing Centers funded by the National Institute of Standards and Technology) with the region's manufacturing industry for problem solving, applied research, generic research, and training.
- The Institute for Advanced Manufacturing Sciences (IAMS) is undergoing a reorganization that bases its services to Cincinnati-area industry on six centers that correspond to strengths of the University of Cincinnati.
- The Edison Animal Biotechnology Center (EABC) aims to commercialize the results of an excellent research program at Ohio University for which there is no local industry; it is about to substitute a broader client base for an exclusive relationship with one corporate member.

Within this diverse program, the committee found the following factors to have been critical to the success of individual Edison centers, regardless of target client and mission:

1. The center is led by an enthusiastic director who seeks and welcomes broad participation from all parties and who actively solicits new members.
2. The center has a clearly defined and realistic mission statement that tailors the state's objectives to fit the local situation.
3. The center builds on the academic, industrial, and community strengths available to it.
4. The work of the center has the enthusiastic support of universities and colleges, including the backing of key administration and faculty.
5. Representatives from industry constitute at least half of a strong, committed board of directors and a scientific project review committee that sets the center's agenda.
6. Industry backing has been demonstrated by financial support, the levels of which may vary by the resources of the specific industries, and by a high membership renewal rate.
7. Effective networking exists with industry and university sources for both technical ideas and advice meeting industrial needs.

The centers have not been equally successful in contributing to state economic development. At most centers, the site visit team found that the senior management and boards of directors had a good understanding of the actions needed to strengthen the center.

Specific suggestions for improving the management of individual centers are included in Chapter 4. General actions that the centers might take are to provide greater attention to training, involve organized labor in the centers, and institute better formal procedures for financial management and performance evaluation of senior center staff.

On the whole, the centers have given good value for the state's investment. Continued state funding of the Edison Technology Centers program is warranted.

Introduction

The Edison Technology Centers Program

In recent years, there has been a proliferation of initiatives by states to enhance their economies by linking their academic and industrial communities. Their objectives are to provide assistance for the health and growth of existing local businesses of all sizes; help create new companies based on technologies being developed in indigenous research institutions, state and private universities, and technical and community colleges; and attract national and international companies to the state. One such initiative is Ohio's Thomas Edison Program.

The Thomas Edison Program was proposed by Governor Richard F. Celeste in 1983, when Ohio had high unemployment and concerns about the long-term viability of the manufacturing sector. It has three elements: nine Edison Technology Centers, a seed development fund, and technology incubators. The program appears to have broad-based support from Ohio's state and national elected officials of both political parties, from owners and employees of large and small companies, and from academic faculty and administrators.

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The Edison Technology Centers, which are the focus of this committee's study, receive 80 to 85 percent of the Thomas Edison Program's budget. Each center is a three-way partnership among industry, academe, and government. The state allows a great deal of latitude in how the centers are organized to meet the broad state goals of linking the academic and industrial communities to provide economic benefit to the state. The first six Edison centers were authorized in July 1984; three additional centers were authorized in August 1986. Because some centers experienced start-up delays, the centers have actually been in operation for 2 to 5 years. Each center addresses a class of related technologies and serves either its nearby region or a more widespread clientele in the state or beyond its borders. There is no normative model for a center; each one is unique.

The Ohio Department of Development asked the National Research Council to review the centers' missions and objectives and to evaluate their accomplishments and prospects. In addition, the National Research Council has an interest in drawing more broadly applicable conclusions about promising strategies for developing, implementing, and evaluating state technology initiatives.

The National Research Council formed the Committee to Review the Ohio Thomas Edison Technology Centers to perform three tasks:

1. evaluate the performance of the individual Edison centers in early 1990,
2. make some judgments about the overall Edison Technology Centers program based on its concept and the performance of the centers, and
3. identify factors that appear to be important to the success of such state economic initiatives and that might be broadly applicable not only in Ohio but also in other states.

The present report summarizes the judgments of the committee based on their findings from visits to the centers and on the state's criteria for successful performance by the centers. These criteria are listed in the Edison Technology Center funding guidelines as follows:

1. Economic development—job creation and retention, as well as business development and expansion, in Ohio
2. Increase the competitiveness and productivity of existing Ohio companies through technological innovation
3. Diversification of Ohio's economy—creation of new businesses and/or industries in Ohio
4. Formation of effective partnerships and consortia involving the private sector, colleges and universities and government
5. Development of the highest possible technical competence given the field or area of technology
6. Development of financially and scientifically viable institutions
7. Establish and improve education and training programs to meet the needs of the work force now and in the future

Each center could be expected to select certain of these multiple criteria for emphasis, depending on individual circumstances and opportunities. This did happen. The committee has attempted to draw some general conclusions about approaches that appear to work well and difficulties that can arise in responding to the criteria. It is unlikely that any center can excel at all seven criteria, particularly 3 and 5. In the committee's view, all centers should ultimately contribute to regional economic development, if nothing else.

Study Methodology

The committee was chosen so that each member could effectively represent at least one (often more) of the three constituencies—government, industry, and academe—being brought together to achieve the Edison centers' purposes. In addition, the areas of technological expertise of the committee members mirrored those of the centers. No one who was a resident of Ohio was eligible for membership on the committee.

At an initial planning meeting in Columbus, representatives of the Ohio Department of Development provided an overview of the Thomas Edison Program and the aims of each center. The committee then prepared a set of questions to be asked during its visits to each center. The questions are listed in Appendix A.

Each visit was attended by one to three committee members and one or two staff members of the National Research Council. An additional expert in the principal technical topic of the center also participated in the site visits to some centers. Each committee member participated in one to three site visits, and one staff member visited all nine centers. A complete list of site visit participants is presented in Appendix B.

On the first day of the site visits, the visiting team typically met with the director and staff of the center for presentation of goals, programs, and accomplishments and with representatives of the center's governing board, the committee responsible for project definition and selection, and industrial and academic members of the center. Most visits included interactions with a variety of individual and corporate participants in the program. The second day of the visit was left for clarification of residual issues and questions and for report preparation.

This process was necessarily subjective because of limited time, differing compositions of site visit teams, and differences among the centers' missions and organizations. The committee

discussed at length the standards used to judge the centers and the findings of the site visit teams. The site visit teams are confident that no major items were overlooked or misinterpreted and that they were able to learn a great deal from each visit. The careful preparation of the Ohio Department of Development helped accomplish this, as did the open and frank discussions with the various constituencies of each center.

Judgments about each center were based on committee observations of the following considerations:

- the center's choice of technical program;
- the technical excellence of the particular program and its appropriateness to the needs of the center's participants;
- examples of technology transfer, as appropriate, through either generic means (e.g., short courses or training programs) or company-specific activities;
- the apparent contribution of the center to regional economic development (by the number of participants, financial and in-kind contributions, testimonials, or truly tangible economic development measures);
- the strength of the center's key managers, as reflected by their demonstrated grasp of goals, staff leadership and management ability, credibility in the research community, and outreach to the industrial community;
- the enthusiasm, expertise, influence, and level of participation of the board of directors, reflecting their role in shaping the mission, measuring and recognizing performance, and helping to ensure a high level of community participation;
- the integration of center programs into the core of industrial activities as well as into the core research and education functions of the participating universities, colleges, and other institutions;
- the stability of funding sources and the long-term viability of the center in the context of reasonable expectations about the availability of industrial and federal funds and donations of in-kind goods and services; and
- the scope of the center's activities for its regional (metropolitan area) versus more distant industrial participants.

Following the site visits and preparation of site visit reports, the committee met again to discuss the reports, evaluate the program, and draw some general conclusions about state technology initiatives. This report contains a summary of the centers' activities, with an emphasis placed on lessons that can be applied from these centers to other technology assistance initiatives. The criteria for review in Chapter 2 are followed by cross-center findings in Chapter 3, findings at the individual centers in Chapter 4, and conclusions and recommendations in Chapter 5.

Criteria for Review

The primary basis for judging the performance of an individual Edison Technology Center should be its choice of target community and how effectively it serves that community. The diversity of center missions permitted under the Edison Technology Center guidelines suggests that the first step in evaluating a center is to identify its mission and target communities.

The Edison centers' target communities represent a continuum from the smallest of local businesses located near the center to the largest of multinational corporations, including some without a local presence. The academic participants also represent a continuum from community colleges with a local focus to world-renowned research and educational institutions. As a means for focusing the discussion, the committee found that center activities could be grouped into three broad categories:

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I. Problem solving, training, and transfer of existing technology as services to technologically less sophisticated, usually smaller, companies.

II. Development of state-of-the-art knowledge and transfer of that knowledge, usually from universities to larger companies.

III. Commercialization of cutting-edge research from universities, medical centers, or the Edison center itself, sometimes by creating new companies.

Category I activities are clearly driven by the needs of the center's clients, whereas at the other end of the spectrum, category III activities originate with the opportunities presented by research. Category II activities respond to a combination of needs and opportunities. The categories of activities that a center chooses to undertake are determined in large part by the region's resources, and centers often offer services in more than one category. Regions with a large number of traditional manufacturing companies tend to offer category I activities in response to demand, whereas centers near nationally or internationally known research facilities are likely to offer category III activities.

Category I activities stem from the recognition that manufacturing companies continually need to upgrade their manufacturing processes, enhance product quality, increase their responsiveness to competitive forces and changing market demands, and have well-trained, productive, and flexible work forces. Many smaller enterprises, in particular, lack the expertise to make critical decisions about changes in technology, operating procedures, and staff training. For these companies, outside assistance can make the difference between survival and failure. Centers engaged in category I activities might provide such useful services as:

- client-specific technical problem solving,
- client-specific strategic planning assistance,

- client-specific business management assistance,
- training, which might be client-specific,
- networking with other smaller firms,
- networking with prospective customers or suppliers, and
- opportunities to learn about or try new technologies and processes.

These activities are unlikely to reach companies located beyond the effective day-to-day operating radius of the center (about 30 miles). Although these activities might not have unique intellectual content and might not achieve recognition beyond the region, they can meet fundamental industrial needs directly and effectively. Even if neither the local companies nor the local academic institutions have unique resources, the marriage of industry and academe for a common purpose can be a powerful technological and economic tool.

The value of these activities is determined primarily by their impact on the small-business community. As impact data per se are difficult to identify, surrogates must be used. Such measures might include the number of participants in various activities, changes in procedures or equipment made in response to advice, the willingness of companies to pay part of the cost of the activity, and the perceived quality of the activity compared with that of similar work done elsewhere.

Category II activities are aimed at providing service to a broader range of industrial clients, whether they are independent local enterprises or branches of national or international firms, that are relatively sophisticated in their use of technology. Unlike category I clients, these firms are usually larger and have moderate to strong technical competences in their in-house staffs. They, too, however, need access to current technological developments and to specialized university-based skills. Thus, the principal interactions between the center and the firm are in such areas as:

- state-of-the-art postgraduate education and advanced-technology familiarization,
- joint research in advanced problem solving,
- generic research to advance the state of the art,
- specialized training for parts of the local work force, and
- harvesting of ideas from recent academic work for use in industry.

Because person-to-person interactions can contribute to a successful effort, these activities often link companies and universities in the same region. Companies located farther away might participate when the research activity within a region is strong.

Category II activities involve both broad-based research of general interest to the industrial sponsors and company-specific activities. Although this research is usually done at one or more universities, some Edison centers also have their own research facilities. Generic research is generally supported out of center membership fees, while company-specific research is paid for separately by the company. By assembling multiple corporate sponsors, the center can support high-quality applied research.

Companies are attracted to the activities offered by the centers in part because they help to establish collegial relationships between technical leaders in industry and university-based researchers. As a result, companies have access to current developments and to university experts for research, training, and specialized advice. Universities benefit not only from the added research funds, but also from opportunities for students and faculty to work with realistic, practical problems.

The value of these activities is measured by the level of participation of the target industrial community. After an initial period, these activities should become self-sustaining. The companies that use the results of generic research are getting leverage for their investment; if they are getting

value, they will continue to invest. Further, if the center is helping the company in its relationships with academe, company-specific research through the center is also likely to continue.

Category III activities, rather than being driven by the needs of current industry, focus on harnessing for commercial gain cutting-edge research that is resident within a state's university or not-for-profit research community. Centers engaged in category III activities promote economic development by tapping certain unique local research activities that are often nationally or internationally known. Such development can take any of several forms:

- transference of cutting-edge research to an existing local industry (large or small) for commercial use;
- attraction of national or international firms to the region to benefit directly or indirectly from research at universities or research institutions;
- creation of start-up firms backed with local or more broadly gathered venture capital and based on locally undertaken cutting-edge research; and
- licensing of locally undertaken cutting-edge research to firms within or outside of the region.

Category III activities are most easily accomplished if a sophisticated industrial user of high-technology research is present locally. In the absence of a local industrial base, a major question is whether the center should attempt to create a local base (either by creating new local firms or by attracting from elsewhere firms with this focus) or should seek a broader audience by providing licenses to any prospective user. Category III activities are often attractive to companies outside the region.

The value of category III activities is indicated by such simple measures as numbers of technology spin-offs, new firms attracted to the area, and licenses. There are two measurement problems, however. First, it takes 5 to 10 years or more to bring cutting-edge research to the point of commercial readiness. Thus, if centers are creating, attracting, or expanding industry based on research sponsored by the center, the region will not experience the full economic benefit for several years. Second, many commercialization efforts and start-up companies fail, although those that succeed have the potential to help the state economy significantly. Thus, centers that are successfully engaged in category III activities can expect to receive a large payback from the success of only a small percentage of their activities.

All three categories of activity can contribute to state economic development. Centers engaged in any one of these activities are legitimate components of the Thomas Edison Program. The accomplishments of a center should be judged relative to the activities it undertakes.

4 Cross-Center Findings

This chapter describes the Edison Technology Centers and their impact, along with observations about the diversity of center activities, center performance, center management, and keys to success.

Diversity Among the Centers

Target Communities

Each of the activities encompassed in the charter of the Edison Technology Centers program—problem solving, technology application, industry-university linkages for research, and development of local industry on the basis of results of outstanding, locally based research facilities—is being competently provided by at least one center, but no Edison center is successfully providing all of them. Each center can be described as having primary and, in some cases, secondary missions in one or more of the categories described in Chapter 2. The committee's categorization of the activities of the nine Edison centers is given in Table 3-1.

TABLE 3-1.
Categorization of Activities of the Edison Technology Centers

	Category I	Category II	Category III
AITRC	Secondary	Secondary	Primary
CAMP	Primary	Secondary	Secondary
EABC	Little or none	Little or none	Primary
EBTC	Secondary	Secondary	Primary
EISC	Primary	Little or none	Secondary
EMTEC	Primary	Secondary	Little or none
EPIC	Primary	Primary	Secondary
EWI	Primary	Primary	Little or none
IAMS	Primary	Primary	Little or none

Notes: Center acronyms are as follows: AITRC, Applied Information Technology Research Center; CAMP, Cleveland Advanced Manufacturing Program; EABC, Edison Animal Biotechnology Center; EBTC, Edison BioTechnology Center; EISC, Edison Industrial Systems Center; EMTEC, Edison Materials Technology Center; EPIC, Edison Polymer Innovation Corporation; EWI, Edison Welding Institute; IAMS, Institute for Advanced Manufacturing Sciences. Cate-

gories I, II, and III are explained in Appropriately, each center is designed to take advantage of unique resources in its community. Most communities have small companies that need assistance, and most centers offer such category I assistance. Six centers offer these services as a primary mission; of the other three, two are involved with emerging industries that do not have an established base of local industry that needs category I services.

Centers with access to leading universities or other research facilities are undertaking category II and III activities, depending on the needs of local industry. Two of the three centers that are undertaking category III activities as a primary mission are trying to create a new industry based on the results of cutting-edge research.

Sphere of Influence

Centers can also be categorized by their clientele or sphere of influence. Many centers were created to enhance the local industrial community. These centers are often excellent in their technical quality and influence—indeed, they may be worthy of imitation elsewhere—but they serve a local client base.

Other programs are intended to reach beyond local, or even state, boundaries. In some instances, this is because potential beneficiaries are too widely scattered to sustain such a facility at a local level. In other instances, the facility may be regarded as so outstanding that its activities are of interest to a far broader community.

The Edison centers are about evenly divided between those with regional and those with broader orientations, as shown in Table 3-2. Centers with a primarily regional sphere of influence are CAMP, EBTC, EISC, EMTEC, and IAMS. Those with a wider outreach are AITRC, EABC, EPIC, and EWI. This is not to say that those with a broad reach have little interest in or impact on local industry, nor that those with a regional orientation do not serve companies outside their regions.

TABLE 3-2.
Further Categorization of the Edison Technology Centers

	Category			Sphere of	Staff and
	I	II	III	Influence	Facilities
AITRC	S	S	P	Broader	Facilitator
CAMP	P	S	S	Regional	Facilitator
EABC	O	O	P	Broader	Researcher
EBTC	S	S	P	Regional	Facilitator
EISC	P	O	S	Regional	Both
EMTEC	P	S	O	Regional	Facilitator
EPIC	P	P	S	Broader	Facilitator
EWI	P	P	O	Broader	Both
IAMS	P	P	O	Regional	Both

Note: P = primary, S = secondary, O = little or no activity.

Interestingly, the spheres of influence are independent of the three categories of activities. EPIC and EWI effectively provide category I problem solving beyond their local area.

Sponsorship, the source of funds to support the center, generally parallels the center's sphere of influence, but there are exceptions. CAMP, which is primarily oriented toward revitalizing the Cleveland area's manufacturing community and is funded primarily by that community, has also captured the attention of the federal government's National Institute of Science and Technology, which has awarded CAMP $3 million in funding as one of three Manufacturing Technology Centers. Similarly, EBTC was instrumental in attracting federal funds to the Cleveland area for research on Functional Electrical Stimulation. On the other hand, AITRC, with a potentially global programmatic impact, has had exclusively local sponsorship.

Organization for Program Implementation

Some centers actively engage in research within their own facilities and with their own personnel. In others, the staff facilitates the conduct of such research by brokering relationships among sponsors and research facilities, primarily but not exclusively at universities. Neither approach is intrinsically good or bad, and in some instances the approaches are taken simultaneously. The approach that a center takes influences its organizational structure, requirement for facilities, means for reimbursing researchers, and potential flexibility and responsiveness to sponsor needs.

As shown in Table 3-2, EABC and EWI have major in-house facilities in which the research work of the center is conducted. EISC, although primarily a facilitator, conducts some in-house research, and IAMS, with a major new facility, will have the potential to do so as its program evolves. The other centers facilitate the conduct of research at affiliated universities, hospitals, and research centers.

Center Performance

Because the Edison program has economic concerns in three of its seven criteria for successful center performance, the committee initially looked for quantitative results during its visits. It rapidly became clear, however, that the multipurpose programs and the impossibility of conducting controlled experiments prevented this. Qualitatively, some centers excelled in some areas but lagged in others, and instead of attempting to provide an unjustifiable average score, the committee concentrated on individual observations about each center.

Assistance to Regional Industry

At all eight of the centers that had category I activities, the committee heard enthusiastic comments from small businesses that have joined the centers or participated in their activities. Centers offered such services as seminars, symposia, data base searches, answers to questions about immediate business needs, and on-site surveys of a company's business and manufacturing practices. Most small-company participants reported that they had no place else to go for the types of assistance and information they received from the Edison centers.

Center clients, staff, and boards of directors have numerous anecdotes describing saved or created jobs. While every center has such anecdotes, only two will be given here. A 15-person company in the Dayton area was about to lose its major contract (and therefore go out of business) because it was unable to solve a production problem. The company called EMTEC, which in turn called an EMTEC member who was able to solve the company's problem. In a second example, EBTC opened a new market and product line for a small, local company by linking it to the needs of the Functional Electrical Stimulation Center at MetroHealth Medical Center. While causality is

often difficult to prove and benefits can be difficult to measure, there is clearly an enthusiastic industrial clientele for the Edison centers throughout the state.

The Edison centers have brought a mixture of state-of-the-art and utilitarian technology to local industry. They have given university staff the opportunity to do state-of-the-art research relevant to industry. As a result of the centers' activities, the university staff and, in some instances, the corresponding industry research staff have been able to sustain a higher quality of technical expertise. At the centers with multiple examples of technology transfer, industry played a dominant role in selecting projects, setting technical directions, and identifying projects ready for commercialization. The centers have created a broad community of interest where previously it did not exist.

Technological Excellence

Technological excellence is fundamental to category III activities. The two biotechnology centers, which have primary missions in this category, have access to excellent research institutions, and they aim to translate this research into a form that will benefit Ohio's economic base. AITRC, in contrast, hoped to invent its own world-class technology. EBTC took the approach of serving as an active agent, constantly seeking small companies to match with aspects of the research programs. EABC, like AITRC, hoped to benefit directly from the technology it was promoting, as a means of becoming independent from state funds.

For some Edison centers, application of cutting-edge technology was part of their category II activities. EPIC draws on two world-renowned polymer research universities to serve its larger clients, EISC's computed tomography has the potential to be pathbreaking, and some of EWI's work is also at the cutting edge.

The prestige of an Edison center based on commercializing research results can provide benefits to the state of Ohio. Even in the case of EABC, where part of the spin-off company has left Ohio for extrinsic commercial reasons, Ohio is still benefiting from the increased visibility that the Edison center program brings to excellent research at a local university. In addition, there has been local commercial spin-off activity.

An exclusive relationship between a center and one or two of its member companies, however, has potential drawbacks. At EABC, management attention is being diverted from the main mission of the center to resolve technical and legal complications from such a relationship. Promoting start-up companies is a legitimate Edison center mission, however, and EABC had no local industrial base. At AITRC, which did have a local industry, attempts to channel research results into a start-up company led to competition with the business missions of the other commercial partners.

Training

All Edison centers provided some education and training activities through seminars, symposia, and, indirectly, the training of graduate students through funds for research. At some centers, however, the education was incidental to the research program, and training was secondary to problem solving and research.

The committee sees an opportunity for the Edison centers, especially those involved with manufacturing and materials, to play a greater role in industrial training. These centers might serve as links between the universities and the community colleges, to help the community colleges provide training that would be as up to date as possible in addressing industrial needs. The participation of the Unified Technologies Center in CAMP might serve as a model for others.

Center Management

Staff

The center director seems, in every case, to be critical to the center's ability to bring its diverse constituents together to the benefit of Ohio's economy. Effective center leadership requires that the top management have a mixture of technical and commercial expertise, leading to the ability to gain the trust and support of academic and industrial partners. In some centers these two types of expertise are provided by the same individual, while in others they are provided by two people who act as a management team. Examples show that both approaches can work well.

Every center that primarily serves as a facilitator has a small administrative staff. Centers that primarily serve as technology service centers have technical staffs ranging from sizable at EWI and EABC to moderate at EISC (and in transition at IAMS). In all centers, staff sizes are appropriate to the mission.

The site visit teams were generally impressed by the capabilities of the center staffs, although in some cases the staffs seem to be growing too quickly to be adequately trained and in other cases staff capabilities may not run deep in the organization. Procedures for evaluating staff performance were inconsistent. There might be a role for the boards of directors or the state in instituting a formal performance review for senior staff members.

Diversity is a strength of the Edison Technology Centers because it allows each center to build on unique local resources. Nonetheless, interactions among all Edison centers regarding administrative matters and interactions between centers involved with the same technology area (e.g., biotechnology) are sporadic but potentially beneficial. The goal of such interactions should not be to impose uniformity but, rather, to give centers an opportunity to learn from each other's successes and to seek areas of useful cooperation between centers whose strengths complement one another.

Governance

There is considerable variation in the composition, technical and business expertise, and assertiveness of the boards of directors at the various centers. Despite state guidance, EABC and IAMS do not have a majority of board members drawn from industry and their chairmen are from academe rather than industry.

The active involvement of established industrial companies in the direction and management of the centers is a basic principle of the Edison program and is one of its strengths. The committee observed strong involvement by those companies in most of the manufacturing and materials centers; however, few such companies exist locally for the two biotechnology centers (EABC and EBTC). Involvement is most effective and convincing when the companies are prepared to make meaningful cash contributions to support the center's work. Receipt of a large part of industrial matching funds as in-kind contributions is an indication that the financial commitment is weak.

The committee observed that organized labor has little direct involvement in the centers. The state of Ohio might wish to consider whether such involvement could be helpful to the program, particularly in cities such as Toledo and Cleveland, which have traditionally had active labor organizations.

Financial Management

Financial control ranges from good to mediocre. There was no uniformity among the formats of the financial reports presented to the committee, which is a problem only to the extent that

some centers fall short of good business accounting practices. A requirement for uniformity could ensure that such practices are followed.

The Edison program office exercises financial control by requiring independent audits and by releasing funds quarterly and withholding them if the matching funds are insufficient or unsatisfactory or if the center has not demonstrated a need for state funds. The state has shown a willingness to withhold funds from at least three centers.

State Funding

The most obvious contributor to the success of the Edison centers is state funding. That funding made it possible for various communities in Ohio to build on existing technical resources to support and develop the state's industrial base. Existing relationships between industry and academe were strengthened in all instances and many new relationships were initiated. Although state funding has resulted in significant matching contributions from industry, it remains vital to the continued successful evolution of every one of the surviving centers. Industry contributions have been most meaningful when they reflect value received in terms of advice or research as opposed to being mere expressions of civic responsibility.

The times needed to establish the three broad categories of activities performed by the Edison centers (technical assistance, technology transfer, fostering commercialization of emerging technologies) vary widely. Unfortunately, those activities most likely to contribute ultimately to center income take the longest to get established. Technical assistance to small companies can be provided almost immediately, but in most instances it provides little revenue to the center and must be subsidized. On the other hand, the successful commercialization of an emerging technology could provide significant license royalty income, but its realization can take a decade or more; even then, most of the benefits are through community job growth rather than income.

Most manufacturers have a product cost structure that is about 50 percent purchased materials and components, much of which comes from smaller firms. To be competitive, the larger firms must have access to efficient, capable suppliers. Therefore, services to small and medium-sized firms benefit all of industry.

The funds provided to firms have multiple paybacks in the public domain. These include such benefits as employment stability and diversification of the economy. The most direct paybacks are income taxes on workers and property taxes on assets, both currently and in the future. Firms tend to distribute their funds for goods and services locally. These goods and services are, in turn, taxed. The foregone costs of unemployment, training, welfare, and deterioration of assets must also be considered in a fair evaluation. Furthermore, support of small companies is justified as a public good, analogous to education. Since the larger companies typically draw predominantly on local small companies as suppliers, technical support at this level increases the overall health of the economic system in Ohio. This is, no doubt, part of the reason that large-scale industry tends to be an enthusiastic supporter of many centers.

Keys to Success to Date

The committee identified a number of factors that appear to have been critical to the centers that are deemed to have been the most successful. Conversely, the centers that have been less successful, or that have failed, did not pay adequate attention to one or more of these factors. These keys to success describe the internal working of the centers rather than their results. While the state might not wish to rely entirely on judgments about each center's performance on the keys to success, the committee believes that there is a strong correlation between the keys to success and the state's guidelines. The following list is not in order of priority; all are important.

1. The center is led by an enthusiastic director who seeks and welcomes broad participation from all parties and who actively solicits new members.
2. The center has a clearly defined and realistic mission statement that tailors the state's objectives to fit the local situation.
3. The center builds on the academic, industrial, and community strengths available to it.
4. The work of the center has enthusiastic university and college support, including the backing of key administration and faculty.
5. There is active representative industry participation as exemplified by a strong, committed board of directors and an active scientific project review committee.
6. Industry backing has been demonstrated by financial support, the levels of which may vary by the resources of the specific industries, and by a high membership renewal rate.
7. Effective networking exists with industry and university sources for both technical ideas and advice meeting industrial needs.

For each of these success factors, the committee evaluated whether each center's performance was very good, moderately good, or in need of improvement. Several centers were performing all of these success factors very well, but most of the centers were performing some success factors better than they were others. It is interesting to note that a majority of the centers were performing each of the seven success factors listed above very well, which is another indication of the overall success of the program. The following discussion describes, factor by factor, how the centers performed.

1. *The center is led by an enthusiastic director who seeks and welcomes broad participation from all parties and who actively solicits new members.*

Five centers—CAMP, EBTC, EISC, EPIC, and EWI—were performing very well along this dimension. Two centers were performing moderately well for different reasons: AITRC's director is enthusiastic but does not seek broad participation, while EMTEC's director is enthusiastic and welcomes broad participation but not the broad sharing of authority. Finally, two centers, EABC and IAMS, are in transition. EABC is operating under a new director and the committee felt it was not possible to evaluate EABC on this dimension until the director—whose credentials are promising—has had more time. IAMS is being managed by an interim president, and its ultimate leadership will not be determined for another 9 to 12 months.

2. *The center has a clearly defined and realistic mission statement that tailors the state's objectives to fit the local situation.*

Five centers—CAMP, EABC, EISC, EPIC, and EWI—were performing very well along this dimension, and two centers—EBTC and EMTEC—were performing moderately to very well. The committee is generally impressed with the clarity of their missions but wonders whether EBTC's mission is sufficiently narrow to be achievable and whether EMTEC's is sufficiently broad to have a major impact. One center, AITRC, had an unrealistic mission, which appears to have contributed to its board's decision to terminate operations. Finally, it is not possible to evaluate IAMS along this dimension until its reorganization is complete.

3. *The center builds on the academic, and industrial, and community strengths available to it.*

Seven centers—CAMP, EABC, EBTC, EISC, EMTEC, EPIC, and EWI—were performing very well along this dimension. One center, AITRC, was performing poorly and will be terminating operations soon. Finally, one center, IAMS, is undergoing reorganization. While the promise of significant and high-quality university-industry linkage is great, it is not possible to evaluate IAMS along this dimension until its reorganization is complete.

4. *The work of the center has the enthusiastic support of universities and colleges, including the backing of key administration and faculty.*

Seven of the centers—CAMP, EABC, EBTC, EISC, EMTEC, EPIC, and EWI—were performing very well along this dimension. IAMS has the enthusiastic support of the University of Cincinnati for its reorganization, but it is too soon to know whether this support will continue and will expand to include other universities and colleges. AITRC established good working relations with the academic community in Pittsburgh but not in Ohio.

5. *Representatives from industry constitute at least half of a strong, committed board of directors and an active scientific project review committee.*

Six of the centers—CAMP, EBTC, EISC, EMTEC, EPIC, and EWI—were performing very well along this dimension. The EMTEC board of directors, although committed to the center's program and actively involved in directing research projects, is not as strong in establishing center policies and programs. AITRC was performing moderately well with a strong, committed board of directors but a less effective project selection process. One center, EABC, was performing poorly because it only has one industrial member, but EABC recognizes the need to broaden its industrial participation and has begun to do so. Finally, the likely performance of IAMS on this dimension is hard to evaluate. Its industrial members are clearly committed to working for the success of the new organization; if IAMS provides a set of services and an organization that are distinct from those of the University of Cincinnati, then industry participation will indeed have been a key to success.

6. *Industry backing has been demonstrated by financial support, the levels of which may vary by the resources of the specific industries, and by a high membership renewal rate.*

Six centers—CAMP, EBTC, EISC, EMTEC, EPIC, and EWI—were performing very well along this dimension. IAMS was performing moderately well, but it appears that the reorganization will lead this center toward good performance along this dimension. Finally, two centers—AITRC and EABC—were performing poorly. As mentioned above, AITRC is terminating operations, and EABC recognizes the need to expand the level of participation by industry.

7. *Effective networking exists with both industry and university sources for technical ideas and advice meeting industrial needs.*

Seven centers—CAMP, EABC, EBTC, EISC, EMTEC, EPIC, and EWI—were performing very well along this dimension. One center, AITRC was performing moderately well. Finally, one center, IAMS, is undergoing reorganization, and it is not possible to evaluate IAMS along this dimension until its reorganization is complete. Networking among groups that have not worked together easily in the past is a difficult undertaking. The fact that no Edison center performed poorly on this dimension is a credit to the program's concept and execution.

Findings at the Individual Centers

The summaries of the nine Edison Technology Centers provided in this chapter give general descriptions of the activities of each center. Because any order of the summaries would be arbitrary, the committee has listed them here in the order in which they were visited. Appendix B contains site visit dates and participants.

Edison Polymer Innovation Corporation

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The Edison Polymer Innovation Corporation (EPIC) brings together three groups: a small EPIC staff, which serves as coordinator; two internationally known polymer research institutions, Case Western Reserve University (CWRU) and the University of Akron (UA); and about 80 corporate members. The center operates at three locations: the two university campuses and a small office between the two. Its mission is to create and commercialize polymer technologies.

The office staff currently consists of six people; an additional position of liaison to small industry should be filled shortly. Although the director is technically trained, the staff's strengths are not primarily technical. Rather, they concentrate on membership development, technology transfer, and problem solving. This staff is appropriate for a facilitating organization.

The center is governed by a Board of Trustees, which is supported by a committee structure. The Board of Trustees and the committee that evaluates research proposals are both controlled by industry. Industry representatives have important positions in their companies—typically, vice president of research and development—and actively support the center.

CWRU and UA both have technically strong programs in polymers. Their combined available staff and pool of graduate students approach 400. Most bench-scale research is done at CWRU, while the applied work—including four applied polymer technology centers—is largely done at UA. Two more centers, for recycling and composites, are under consideration. EPIC's work is at the cutting edge of technology or is well on its way to being so.

When the EPIC staff judge a research project to be nearly ready for commercialization, they poll the members for interest in the project. EPIC's members either sign away their rights to the technology, or they express interest by paying $1,000 (which discourages members from expressing interest in all EPIC technologies). The EPIC staff aims to get interested members to form miniconsortia that will undertake further development of the technology and pay for the patent. If no members are sufficiently interested in a research project, then it is dropped. In one case, where several companies each wanted exclusive rights to a technology, negotiations occurred until one company did secure exclusive rights.

Special accomplishments of the center include the following:

- increased cooperation between UA and CWRU,
- support by most polymer companies in Ohio and many worldwide polymer companies,
- innovative use of membership fees: half supports generic research and half supports company-directed research or problem solving,
- innovative approach to intellectual property issues, and
- high ratio of projects that reach the technology transfer stage (20 percent).

Among the contributors to its success are that it:

- builds on local strengths,
- necessitates interdependency between parties,
- has a clear mission and effective staff, and
- has strong industry and university support.

While the center is well positioned to get an increasing percentage of its funds from other sources, it will need state funding for at least several more years. Its prospects for continued success are high, and the center is an important model of university-industry cooperation. In the future, the center might benefit from better articulation by industry of industry's needs for the generic research program. Another area for attention is greater involvement of the center in the creation of training partnerships.

Edison Materials Technology Center

The Edison Materials Technology Center (EMTEC), based in Dayton, Ohio, has 46 industrial members, 9 academic members, and 9 government laboratory members (primarily at Wright-Patterson Air Force Base). The majority of industrial members are located in Ohio and there is a good mix of small, medium-sized, and large companies.

The center views its mission as creating jobs and assisting industry in Ohio, particularly in the Dayton area. It pursues this mission through a range of short-term problem-solving and applied research and development (R&D) projects. EMTEC emphasizes low-risk projects and has used its problem-solving capability as an effective member recruitment tool. Published goals call for improving materials performance and developing alternative materials and processes.

The center's director exercises tight control, which unfortunately tends to limit the center's programmatic perspective. The Governing Board of EMTEC comprises one board member each from most of EMTEC's member groups (small companies with annual revenues below $5 million are excluded). The board is active, and meetings are well attended.

The Technical Steering Committee (TSC) comprises one member from each of EMTEC's member groups, including small companies. The chief scientist on staff serves as the TSC chair ex officio. This lively forum is the principal source of EMTEC projects and is responsible for reviews and selection of proposed projects, establishment of work plans and budgets, and reviews of all work.

Core technology projects are selected on an annual cycle, largely as a result of discussions at TSC meetings. In a very short time, the cooperative research has established EMTEC's credibility in the eyes of many of the industrial participants. Technology transfer occurs within a given project because each program has a mix of participants; data were not available to ascertain how effective the reporting mechanism was in disseminating project results to EMTEC members that were not project participants.

EMTEC is designed to be responsive to regional economic development by its basic structure and operating methods. The Request for Help program has been an important tool in making industrial companies aware of EMTEC, and the success rate in solving problems is good (63 out of 65 requests). There have already been some regional benefits from the Requests for Help and the continuing willingness of EMTEC members to help each other. This is of particular importance to the smaller companies, which can get tremendous leverage for a very modest membership investment.

The long-term benefits to Ohio from EMTEC are harder to assess. The current plan has specific goals; the projects are generated and driven by members, and it is highly likely they will achieve their goals. The present scattershot approach to selection of research projects was a reasonable way to start the center. EMTEC has now reached a level of maturity at which it might increase the returns to the Ohio economy by reducing its emphasis on Requests for Help and focusing its core technology program on a few high-payoff areas. Two promising possibilities are the center's work in castings and three-dimensional stereolithography.

EMTEC's graduated membership fees, which range from $750 to $50,000 depending on the member's annual sales, are supplemented by numerous donations. Wright State University provides the office space and utilities, Wright-Patterson Air Force Base does not charge for its services, companies have donated equipment, and members do not charge for assistance given in the Request for Help program. Nonetheless, like other centers, EMTEC would probably not survive long without state funds. Significant funding reductions, although not necessarily fatal, would reduce members' level of commitment and interest.

Edison Welding Institute

The Edison Welding Institute (EWI) in Columbus, Ohio, was founded by a merger of three other organizations: the U.S. members of The Welding Institute (TWI), a well-established organization based in Great Britain with an international membership; the Center for Welding Research at Ohio State University (OSU), a National Science Foundation University-Industry Center; and the welding activities of Battelle Memorial Institute (BMI). By absorbing the U.S. industrial membership of TWI and the industrial members of the Center for Welding Research, EWI began its existence with a large industrial membership. As a result, it got off to a fast start, aided by 5 years of rent-free use of an OSU building.

EWI has 228 industrial members, 59 of which have headquarters or production facilities in Ohio. There is a good mix of large, medium-sized, and small companies, and dues are based on company size. In return for their dues, members are encouraged to take advantage of the expertise at EWI by telephone calls and visits to solve immediate problems, to participate for reduced fees in short courses and industry forums, and to receive the results of EWI- and TWI-sponsored research.

EWI is governed by an elected Board of Trustees that is largely drawn from member companies. The founding members—TWI, BMI, and OSU—each have two seats on the board, but this is far from a majority. The well-qualified Industrial Advisory Board, which is elected by the Board of Trustees, selects research projects deemed to be of interest to a large cross-section of members.

The generic research programs, in general, follow the four principal research areas at EWI (materials, bonding and forge welding, fusion welding and automation, and engineering), but the important new dimension of nondestructive evaluation is being added. Research results are published as Research Reports and Research Briefs, which are available to all members.

OSU is the only U.S. university granting a doctorate degree in welding engineering. The technical capabilities at both EWI and OSU are high. An important part of EWI is the research program, which involves about 25 percent of the annual budget and permits members to participate, at a relatively low cost, in advancing welding technology on a broad front. Projects are largely in the Welding Engineering Department at OSU. EWI staff participate in these programs, and additional basic research results are purchased from TWI.

EWI faces some critical issues in the next few months: (1) the need to clarify its relationship with OSU by resolving such issues as the future rental cost of the facility and the ownership of intellectual property rights; (2) continued center growth by recruiting suitable staff with "people skills," in addition to technical competence, because contact with member companies is an important staff job; and (3) careful selection of program areas on which to focus a concentrated effort for the next several years.

Applied Information Technology Research Center

The Board of Trustees of the Applied Information Technology Research Center (AITRC) in Columbus, Ohio, decided on January 12, 1990, to undertake no new projects and to terminate operations as quickly as possible (estimated to be July 1990). Study of this center was viewed as an opportunity to develop contrasts with centers considered to be successful.

AITRC had set very ambitious goals for itself: (1) to become an outstanding research and standards center for the large electronic data base industry, and (2) to become financially self-sustaining (without state subsidies) quickly. Columbus is a regional focus for such industry, so this would reinforce one of the area's strengths. For reasons the committee could not determine, AITRC chose to downplay the complementary transaction processing industry that is also strong in Columbus. AITRC also had a small-business affiliates program, but it appeared to be ad hoc and not central to the thrust of the center.

Representatives of the data base companies served on the Board of Trustees, but these firms were not enthusiastic partners in the AITRC technical program. Two reasons have been cited: (1) They viewed themselves as potential competitors, and (2) software does not lend itself to mutually beneficial collaboration. A third possibility is that the AITRC director and the Board of Trustees were unable to generate a compelling vision of collaboration, nor did industry provide a compelling reason for collaboration.

AITRC sought to excel at research, but it failed to achieve close university collaboration, especially collaboration with the strong program at nearby Ohio State University (OSU). The committee considers this to be a serious mistake. In the most successful centers, at least one nearby university is an enthusiastic proponent and partner. This was not the situation at AITRC.

At the board meeting on January 12, 1990, the dean of OSU's Engineering Department proposed a reorganization plan in which OSU and a strengthened Board of Trustees would play a more direct role, but the board rejected the reorganization plan.

A significant proportion of the member contributions submitted to gain state matching funds were in-kind. Some of the software contributions are not available in the marketplace, and an objective value could not be placed on them.

The committee agrees that the board's decision to shutdown AITRC in its present format was appropriate. Nonetheless, the electronic information and transaction industry is sufficiently important to Ohio that after time has passed the state might wish to fund a new center to fulfill this industry's needs, if a proposal were received that fit the Thomas Edison Program's needs and resources.

Edison Industrial Systems Center

The Edison Industrial Systems Center (EISC) in Toledo, Ohio, was organized to provide services to the northwestern Ohio industrial community. The center has a strong regional focus and enjoys the enthusiastic support of community leaders, industrial members, and the academic institutions serving the Toledo area.

The primary goal of the center is to serve the needs of local businesses and to enhance their ability to compete. The center is not driven by a desire to invent; rather, it serves its clients by

helping them apply technology—most often, existing technology—to improve their manufacturing capabilities. The goal of EISC is well matched to the needs and technical resources of the greater Toledo community.

There are three membership classes: full (dues of $30,000/year), associate ($15,000/year), and supporting ($5,000/year). Academic institutions, like companies, are dues-paying members. Each full and associate member has a representative on the Technical R&D Steering Committee, which meets monthly. Policy is established by the Governing Board, which meets quarterly and whose members comprise one individual from each of the full members of the center.

The Governing Board established eight core project areas for center activity that were based on industrial interests identified in a survey by the University of Toledo that preceded the center's establishment. Programs outside these core areas require special board approval. Within this basic strategy, the center's approach has been to respond to opportunities as they arise. A challenge, which the Governing Board has the vision to recognize, is to gain member support for activities that are more long term than immediate member needs but that, with EISC support, could be applied to improve their businesses.

The center has selected four general areas for early attention. These range from the mundane (a data base of area resources, which local business members described as very worthwhile) to the technologically advanced (industrial computed tomography), with relatively simple applications of sensors and machine vision systems being in between. The technologically advanced work in computed tomography is aimed at letting member companies test applications rather than conduct research.

EISC impressed the site visit team as a good center with high potential benefit. Center leadership was strong, and the industrial and academic participants were supportive.

Edison BioTechnology Center

The Edison BioTechnology Center (EBTC), a relatively new Edison center, serves primarily as an academic-industrial liaison group. It aims to promote the growth of a medical biotechnology industry in Cleveland by providing industrial support services and brokering academic research programs. Its principal academic members are Case Western Reserve University (CWRU), the Cleveland Clinic Foundation, the University Hospitals of Cleveland, and MetroHealth Medical Center; its industrial members include 34 business sponsors, most having less than $10 million in annual sales. At the member academic institutions, EBTC sponsors research programs with some commercial potential. It also provides business consultations, symposia, and seminars to the commercial membership. EBTC has compiled and distributed a comprehensive directory of members and biotechnology services.

Because the medical biotechnology companies in the Cleveland area are primarily small start-up companies, EBTC's mission is to expand this industrial base. It does so by assisting those companies and by assisting established companies in other fields to move into biotechnology. These companies cannot afford high membership fees, so EBTC looks to federal grants for some of its matching funds.

EBTC is governed by an active Board of Trustees made up of local academic, business, and community leaders, and has a Technical Advisory Committee (mostly from academe) and a Commercialization Committee (mostly from business) to aid in project evaluation and review. EBTC has worked closely with the Functional Electrical Stimulation (FES) program at MetroHealth Medical Center helping to establish it as a national FES center supported primarily by the Veterans Administration and National Aeronautics and Space Administration.

EBTC research funding for programs at the member academic institutions initially has been directed to a large number of projects believed to have some commercial prospects. Program areas include diagnostics (bacterial identification, magnetic separation), therapeutics (photodynamic therapy, mesenchymal stem cell culture, monolayer films), rehabilitation (FES), and biomaterials

and medical devices. EBTC offers training in medical biotechnology only indirectly by supporting the research projects of graduate students and postdoctoral fellows.

In developing academic-industrial liaisons in the CWRU environment, EBTC must cooperate and also compete with University Technologies, Inc., which is the university's patenting and licensing arm, and the Enterprise Development, Inc., component of the university's business school. This situation may complicate EBTC's commercialization activities.

The site visit team was impressed with the enthusiasm of the EBTC staff and their ability to promote biotechnology activity in the local small-business environment. EBTC is more effective in the role of funding smaller short-term programs with more immediate commercial potential (e.g., linking Life Systems, Inc., with a new product opportunity at FES) than it is in the role of directly funding long-term fundamental research (e.g., Skeletech's mesenchymal stem cell therapy, which requires much larger amounts of money for development).

Cleveland Advanced Manufacturing Program

The Cleveland Advanced Manufacturing Program (CAMP) consists of a small central staff, which are located at office facilities donated by a large corporate participant, and five centers located on three academic campuses. CAMP's mission is to provide a variety of services—including research, technology transfer, and training in the use of advanced technologies—to regional manufacturing companies of all sizes. It slightly predates Ohio's Thomas Edison Program, having arisen out of the efforts of Cleveland area industrial leaders to revitalize the manufacturing base.

CAMP has considerable local support, especially from industry, but also from local, state, and federal governments and from consulting firms. Its industrial members include not only such large corporations as Ford and TRW but also small firms whose annual revenues are on the order of $1 million.

CAMP is a large program, involving over 200 individuals (including students) at its five centers. Central administration is handled by a staff of seven, which coordinates the activities of the centers and provides outreach services. CAMP currently has 67 corporate members, and over its 5 years of existence it has received more than $50 million in funding, including $3 million from the highly competitive Manufacturing Technology Centers Program of the National Institute of Standards and Technology (U.S. Department of Commerce). Its necessarily complex organization addresses its multiple objectives of providing research leadership in selected areas, cost-effective applied problem solving for industry, and technology transfer.

The two programs at Case Western Reserve University (CWRU) (the Center for Automation and Intelligent Systems Research and the Edison Sensor Technology Center) appear to be oriented toward advanced generic research the greatest value of which is to larger corporate sponsors, though small companies are also participating in the sensor work. The staff at both CWRU centers have a lively interest in the needs of industry and easy interactions with their corporate peers. They are well qualified in their areas of specialization. The Advanced Manufacturing Center at Cleveland State University (CSU) is more oriented toward engineering problem solving, generally for somewhat smaller local firms with fewer internal engineering capabilities. The work being performed appears to be both sound and of near-term value to its clients, and the staff is attuned to the needs of industry. CSU's ability to undertake practical applied projects is unusual in a university setting and meets a proven need. The center's academic leadership has broad knowledge of and experience in industry, and the program benefits from it.

The centers at Cuyahoga Community College (the Great Lakes Manufacturing Technology Center [GLMTC] and the Unified Technology Center) are also performing well. They are transferring technology through on-site interactions with smaller firms and through training to enhance employee skills. They also advise individual firms on opportunities for enhancing product quality and productivity, which is well received by the business community and which is a valuable activity. As a federally funded Manufacturing Technology Center, GLMTC has a separate mandate and serves a more geographically widespread clientele.

Institute for Advanced Manufacturing Sciences

The Institute for Advanced Manufacturing Sciences (IAMS) in Cincinnati, Ohio, is undergoing a reorganization that was stimulated by the University of Cincinnati (UC) to rejuvenate a fiscally weak and technically mediocre program. The reorganization is progressing well—albeit at an early stage—under the interim leadership of the UC dean of engineering and an active Action Committee.

As before, the primary goal of IAMS is to serve the needs of local companies. It appears poised to offer problem solving to small companies and to serve as broker between larger companies and UC. Although the reorganization is promising, the site visit team has some concern that IAMS is trying to cover too broad a technological area and that it might become a fiefdom of UC. If it is to serve effectively as a broker between industry and academe, IAMS must have an identity and a management team that is distinct from any one group.

IAMS is organizing around six technology centers to build on strengths of UC modulated by the needs of the business community. One of the centers is a new environmental center, which capitalizes on one of the unique strengths of UC and addresses what is fast becoming a critical concern of both large and small companies. This center might find constituency in Ohio beyond just Cincinnati, although it is clearly an important local concern as well.

There are three classes of membership, reflecting the different interests of the small, medium-sized, and large companies. Regular members pay a small base fee plus $10,000 for each of the six technology centers they wish to join. In return, they can assign a person to that center's Technical Steering Committee. Sponsoring members pay a $50,000 fee and receive two complimentary center memberships. They can join the remaining centers upon payment of the standard $10,000 fee for each. They are eligible for, but not guaranteed, appointment of a member of the Board of Trustees. (This is a potentially troublesome point that may warrant revisions of the by-laws.) There is also an affiliate membership category that is expected to be attractive to small companies.

The structure of the Board of Trustees appears to be a holdover from before IAMS was an Edison center. Members are appointed by the University of Cincinnati and the Chamber of Commerce, half of the seats are reserved for industry, and the UC president serves as chairman. Although the board is committed to the success of the center, election of the board and its chairman from among its members might strengthen the center's ability to meet the needs of industrial members and involve other academic institutions.

IAMS is located in a new building on 134 acres of land that the center owns and plans to develop (with professional assistance) into an industrial park. Income from the industrial park could supplement state subsidies to support services to small businesses, but the site visit team has some concern that development of the industrial park could distract from the main IAMS mission and that sufficient thought has not been given to the long-term use of the IAMS building. The imminent construction of a new engineering building at UC might make the IAMS building redundant, unless IAMS offers services that clearly differ from those provided by the university.

While the site visit team did not explore the history of IAMS before the recent reorganization, the perception is that the center did not fully exploit the nearby resources of UC or explore and respond to the major industrial concerns in Cincinnati. These conditions appear to be changing, but the Board of Trustees needs to continue to play an active role in articulating industry's needs.

The new IAMS exhibits vitality from its UC and industrial participants. This bodes well for success, if it can articulate a meaningful mission that responds to local needs.

Edison Animal Biotechnology Center

The Edison Animal Biotechnology Center (EABC) at Ohio University (OU) in Athens, Ohio, is focused on the establishment of novel transgenic animal technologies for modeling human disease, improving farm animals, and conducting basic research into the mechanisms regulating mammalian development. EABC's original aim was to discover and develop applications of the microinjection technique for transgenic animal construction developed at OU.

To realize the commercial potential of its R&D program, EABC formed a spin-off company, Embryogen. Through a complex set of circumstances, Embryogen subsequently merged with Transgenics, Inc., to form a new company, DNX, with headquarters in New Jersey and laboratory facilities in Princeton, New Jersey, and Athens, Ohio. The technical, commercial, and legal entanglements resulting from this business development are currently being resolved following the recommendations contained in the report of the Independent Licensing Group prepared for OU, DNX, and the state of Ohio. DNX's exclusive rights to EABC technology appears to have prevented EABC from developing commercial applications of some of its research. In addition to DNX and OU, the Pig Improvement Corporation (PIC) and a number of academic collaborators from other universities in Ohio are key participants in EABC activities. The commercial development of EABC's activities outside the relationship with DNX is a key objective of the recently appointed director of EABC.

EABC is governed by the Board of Authority. Its seven members include two from DNX and OU's president is the non-voting chairman. As EABC's industrial membership grows, so too should the industrial membership of the Board of Authority. Scientific oversight is provided by the external Scientific Advisory Board, which is made up of nationally recognized experts. It is an excellent group to play a more active role in future program development for the center.

Annual funding for EABC is roughly $2 million, with Edison matching funds coming primarily from federal grants (National Institutes of Health). At present, no funding is provided by DNX. Roughly $1.3 million is spent annually at OU on research programs, primarily in growth hormone regulation and reproductive function, while the remainder of the funds supports work on embryonal stem cells and somatic gene therapy at Case Western Reserve University, transgenic pigs and chickens and virus and bacterial disease resistance in mice at Ohio State University and DNX, and mutagenesis and carcinogenesis models at the University of Cincinnati.

Graduate students, postdoctoral fellows, and laboratory technicians—including the DNX technicians who work with PIC—receive training on transgenic technology capabilities at EABC. The local economic benefits of EABC currently result from the facilities and jobs associated with DNX and the PIC swine growth hormone program. Indeed, EABC was instrumental in PIC's decision to open a facility in Ohio.

While the committee site visit was ill-timed, given the fluid state of affairs with DNX and the recent arrival of the new director, the technical programs appear to be first-rate. Particularly exciting is the yolk sac-hematopoietic stem cell program, which may be especially important in human bone marrow transplantation therapy if the results obtained with mice can be applied to humans. Less obvious is the commercial potential of the swine growth hormone program.

The budgetary and administrative aspects of the EABC operation appear to be disorganized at present. The process for review and selection of scientific programs supported by Edison program funds needs to be made more objective. The functional ties between EABC and other Edison centers (especially EBTC), the other universities, and commercial companies besides DNX (and PIC) might benefit from a more concerted and coordinated effort by the Board of Authority and the OU administration in concert with the external Scientific Advisory Board.

Conclusions and Recommendations

Wide Diversity Characterizes the Edison Centers

The composition and potential contributions of each center reflect the available resources—for example, research universities, government laboratories, sophisticated industrial firms, and local community organizations—and the needs of the communities it serves. Because Ohio's regions have widely varying resources and needs, there is, and indeed must be, wide diversity among center missions and achievements. Under these circumstances, an equal intensity of effort given to each of the seven criteria in the Edison center guidelines is neither necessary nor desirable. This diversity is a strength of Ohio's Thomas Edison Program and should be encouraged.

Center Evaluations Must be Qualitative

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At present, because of center diversity, the absence of hard data, the many indirect ways in which the centers have an impact, and the insufficient time that has elapsed for significant success stories to emerge, the only realistic evaluations of the centers are qualitative. This situation is not likely to change over the next few years. Therefore, the centers should be judged according to evidence of networking, a broad base of industrial and academic support, the willingness of larger companies to invest money and of smaller companies to invest time, and clearly defined missions and programs aimed at regional economic development.

Edison Center Program is Successful

The committee found that the Edison center program is a vigorous, well-managed program that is valued by Ohio's industrial community and is making a significant and growing contribution to industrial competitiveness in Ohio. It is a well-conceived approach to government-university-industry partnerships that reflects Ohio's situation: its several metropolitan areas, its numerous academic institutions, and its industrial base.

Despite the unavailability of quantitative measures of contributions to economic development, the Edison center program has undeniably resulted in significant increases in much-needed technical assistance to small industries across the state of Ohio. Further, it has achieved real progress in transferring technology from research universities to industries of all sizes, and it is fostering the commercial exploitation of several emerging technologies. The evidence presented to the committee of the creation and growth of start-up companies arising from the work of the centers was modest at best, although the biotechnology centers show clear promise and success in this area. Of the nine centers, six are viewed as being successful, stable, growing enterprises, one has a successful record but is undergoing a promising transition to a new management and expanded

clientele, one is undergoing a major restructuring designed to correct past problems, and only one has failed (in its board's judgment as well as that of the committee).

The Scope of Activities is Appropriate

As currently formulated, the Edison centers generally correspond to Ohio's historic strengths in manufacturing and materials and its emerging strength in biotechnology. Accordingly, six of the centers are in fields of manufacturing, testing, or materials that are applicable to a broad spectrum of industrial companies. These centers all place strong emphasis on outreach and technical assistance to small and medium-sized businesses. and on the provision of technical assistance to them. Plans to expand EWI's scope to include non-destructive evaluation and EPIC's mission to include polymer recycling technology and possibly composite materials should be encouraged.

Two centers, EBTC and EABC, are dedicated to research, development, and technology transfer in biotechnology. In these centers the major emphasis is on the development of technologies that may evolve into new or improved products or techniques in the applicable industrial sector. This sector of industry is not yet very large in Ohio, though EBTC has a group of local start-up companies to nurture. Very large payoffs may derive from these centers, but they are unlikely to reach that point for at least another 5 years.

Several broad fields of technology that might be valuable to industry in Ohio are not now covered by the Edison centers. Among these are electronics and photonics, particularly as they apply to products in computing, data handling, and telecommunications; information processing systems and software design; plant biotechnology; and industrial ceramics (unless EMTEC undertakes work in that field). It is possible that industrial demand in these areas is not yet appropriate for Edison centers, but they might add to or replace existing centers in the future.

Suggestions to Improve Technical Programs

Industry should define generic research projects rather than select from among university proposals. This is difficult and may involve considerable compromises, but it could be helpful in increasing attention to and benefits from such projects by industry. Some centers are selecting projects this way, and EPIC's experience demonstrates that a transition to an industry-led selection process can be made.

In the review of projects, some previously announced method of "forced fail" (i.e., discontinuing funding for the bottom x percent of a ranked list of projects) provides an incentive for investigators to make sure their projects are relevant to industry.

The management and licensing of intellectual property and proprietary information is, or will be, an issue in almost all the centers. Experience at other institutions (universities and governments) has shown that most patents do not generate large royalty streams. Thus, emphasis should be placed on proceeding to develop technology in a way that can be effectively utilized (not ignoring protection, where appropriate), but to treat potential licensing income as a bonus and not something to be budgeted as an expectation. As noted in Chapter 4, EPIC's innovative approach to management of the intellectual property that emerges from its research programs may be worth emulating at other technology centers.

If incubator companies are involved in center activities, they can benefit from being located in the same building as the Edison center office or research facilities. EBTC has done this, and EISC proposes to do so shortly. Much of the constant communication that is necessary in start-up efforts is lost when companies are located in rented, off-site facilities.

Excellent Management is Critical to Success

Besides state funding, strong and suitable leadership may be the most critical of all the keys to a successful center. A strong director needs management and leadership skills, an adequate intellectual grasp of the technical field involved, the ability to identify promising directions of collaborative work leading to useful advances, and the ability to command the respect and attention of both industrial and academic participants.

The need to have both business skills (including substantive industrial experience) and technical skills in the director's office means that a single person is often not adequate. In a number of centers, these skills were present in a team made up of a director and an assistant director, which worked well. It does not seem intrinsically important whether the director is strong technically, but if not, a willingness to listen and to understand technical issues adequately remains crucial.

A strong director needs the checks, balances, and support of a strong, industry-led board of directors. In one center, the committee observed a forceful director who was not being adequately challenged by his board; in two others, a single university had great influence over the boards of directors. Industrial members will derive the greatest benefit from the center's program if they influence its content.

The State Should Publicize Keys to Success

The committee finds the following factors to be critical to the ability of centers to achieve the broad state guidelines for the program. While the program benefits from the relative freedom that the state allows each center, these factors should be informally encouraged at all centers.

1. The center is led by an enthusiastic director who seeks and welcomes broad participation from all parties and who actively solicits new members.
2. The center has a clearly defined and realistic mission statement that tailors the state's objectives to fit the local situation.
3. The center builds on the academic, industrial, and community strengths available to it.
4. The work of the center has the enthusiastic support of universities and colleges, including the backing of key administration and faculty.
5. Representatives from industry constitute at least half of a strong, committed board of directors and a scientific project review committee that sets the center's agenda.
6. Industry backing has been demonstrated by financial support, the levels of which may vary by the resources of the specific industries, and by a high membership renewal rate.
7. Effective networking exists with industry and university sources for both technical ideas and advice meeting industrial needs.

Each center director and board of directors should review the success factors that have been identified here and consider the placement of additional emphasis on areas where deficiencies exist.

Training Deserves Additional Emphasis

In the aggregate, the Edison centers have been a strong catalyst in education, particularly at the graduate level, and have created many opportunities for graduate study and research. Several

centers have been instrumental in enhancing training partnerships between educational institutions and industry, but training has not been a priority of every center and may deserve more emphasis.

Continued State Financial Support is Warranted

Even though most centers have growing memberships and levels of service, there appears to be no alternative to continued financial support from the state of Ohio for at least the next 5 to 10 years if the centers are to fulfill their promise.

The centers that primarily offer assistance to small companies, a category that includes the six manufacturing and materials centers, are unlikely ever to be self-sustaining. The clientele for those services are unlikely to have the resources to pay for them fully. While some companies will progress beyond the need for subsidized assistance, others will continually be added to the group of companies that need assistance. From a long-term perspective of overall costs and benefits, steady support of those services by the state can have a continuing statewide benefit.

For some centers, the ability to allocate state matching funds to the purchase of critically needed equipment has been enormously effective in enhancing the capabilities of universities to serve industry through the centers. This ability should be maintained.

The committee judges the general level of state funding for the Edison Technology Centers to be appropriate. It is very small in comparison with the overall technical research fund expenditures in Ohio, of which center funding is a part, and even smaller in comparison with the gross industrial product it seeks to enhance. The application of these funds is seen to be well leveraged and productive, albeit over a long time span. The committee urges the state to maintain at a minimum the current real level of funding for the centers. A reaffirmation by the state of Ohio of continued financial support to those centers that continue to merit it through continuing progress and improvement would be very helpful in maintaining stability, fostering growth, and enhancing long-term planning.

Appendices

Appendix A Site Visit Discussion Form

Questions for Centers

A. MISSION

1. What is the center's mission? How has it changed since 1985 or 1986? How do the center's priorities differ from the state's program priorities?
2. How do you deal with the tensions between serving regional needs and being a world-class technology center?
3. What is your distribution of effort among core research, sponsored research, training, and other services—now and changes over time? Do you feel free to undertake high-risk, potentially high-payoff projects? What portion of your research effort falls in that category?
4. Who is your competition (locally and globally)? What is your competitive advantage?

B. ACCOMPLISHMENTS

1. What criteria do you use to evaluate yourself? How would you change those criteria, and why? How do you rate yourself against those criteria?
2. Examples of successful (and unsuccessful) problem solving for Ohio industry.
3. Examples of successful economic development.
4. What successes and problems do you anticipate over the next few years?
5. What have your biggest successes been? What do you want to do next?

C. MEMBERSHIP

1. What is the distribution of membership (total numbers by year)? Include size of company and location (local, state, national, international). What distribution would you consider ideal? How many members have withdrawn, and for what reasons?
2. How do you go about defining the market (client base and their technological needs)? What is the market? How has it changed since 1985 or 1986?
3. Form of contributions (e.g., cash, building, equipment, software) and changes over time, by type of client (e.g., small local company, Fortune 500 company). Distinguish between membership fees, sponsored research, and voluntary contributions.
4. How would your characterize (a) center staff relationships with the universities? (b) the relationship between the universities and industries that participate in the center? (c) relationships among the participating universities? What changes in university policies might enable you to be more effective?
5. History of personnel assigned to the center from industry (by job title) and amount of time spent on center activities. What form do contacts with industry take?
6. What types of people serve on your board? How do you recruit them? What role does the center's board play? How active is industry on that board?

D. ORGANIZATION AND MANAGEMENT

1. What are the unique advantages of your organizational structure (provided in advance) for your technologies and client base? If you had a free hand, what changes might you make? Why?
2. Distribution of budget from various sources (e.g., industry fees, industry in-kind services, industry donations, state funds, federal funds, contract research), by year.
3. History of employment: total numbers, by year. How much turnover has there been, and why? Where did technical staff go?
4. How visible is the center to local, state, and world industry? How do you create visibility?

E. THE EDISON PROGRAM

1. What would happen to the center in the absence of state funds? What would happen to the center if state funds were reduced by 20-40 percent? What would happen if state funds were increased by 20-40 percent?
2. What is the role played by the state Edison office? What do you wish were different?
3. What areas of overlap or synergy do you have with other Edison centers? What cooperation might be developed? What barriers are there to working with other centers? Should there be more or less interaction among Edison centers? Why?
4. To what extent are you representatives of the Edison program in your part of the state? What is the center's role in the overall Edison program?
5. What are the hardest factors to overcome in creating the Edison center that you want to be?

F. RESEARCH

1. Do you base your reputation on the quality of your research? What constitutes "good" research in your area?
2. How do you bring the benefits of your core research to commercial use? Do you create or spin off businesses? Are patents and licenses part of your strategy? If so, what are projected revenues (for licensees) from patents and licenses over next 5 years?
3. What are the technical skills of the center staff? To what extent does the technical expertise reside on the staff, versus contractual arrangements for technical work?

G. TECHNOLOGY TRANSFER

1. Who is your audience for technology transfer? How is outreach done?
2. What percentage of the budget goes for technology transfer?
3. Qualifications and number of people assigned to outreach/marketing.
4. What are your three biggest technology transfer successes?
5. How many people have moved from the center to industry? Was it Ohio industry? Is this good?
6. Is there a formal sabbatical program between center staff and universities?

H. TRAINING

1. Number of individuals (outside center staff) trained
2. Number of person-hours of training given
3. What evidence do you have that you are providing state-of-the-art training?
4. How often does an Edison technology show up in classes taught by participating community colleges and universities? Give examples.
5. How is the training distributed among technology, process, and methods? List courses given.
6. What organizations benefit from the training?

Questions for Industry

A. Why are you participating in the center?

B. Where would you go in the absence of this center? Would you have sought outside help?

C. How responsive is the center to your calls for assistance?

D. What form do contacts with the center take? How would you like that to change?

E. At what organizational level is the company commitment?

F. Can you live with time scales inherent in center work? When do you expect to receive a payoff from your investment?

G. Has the center's existence influenced your company to stay, expand, or relocate in Ohio?

H. As a taxpayer, do you think the $20 million state investment is worthwhile?

I. Have you used contacts made through the center as consultants?

J. What proprietary research has the center done for you? How happy have you been with the results?

Questions for Universities

A. How does the existence of the center affect the research you do?

B. Do your best students get involved? Your best faculty? What is the reward system for center participation?

C. What are the pros and cons of the center's location on or off campus?

D. How does the center compare with university centers of excellence?

E. What are the mechanics of cooperation with other university partners?

F. What services does the center provide you—right industry people, attract students, add prestige, etc.?

G. What is the reward structure for participation in the center?

Appendix B Thomas Edison Technology Center Site Visits

EPIC: Edison Polymer Innovation Corporation, Akron and Cleveland (January 16-17)
- Mr. George Jasny, Martin Marietta Energy Systems, Inc.
- Dr. Rudolph Pariser, E.I. du Pont de Nemours & Co.
- Ms. Janice Greene, National Research Council

EMTEC: Edison Materials Technology Center, Dayton (January 18-19)
- Dr. Harold W. Paxton (Chairman), Carnegie Mellon University
- Mr. H. Graham Jones, New York State Science & Technology Foundation
- Dr. Bernard H. Kear, Rutgers University
- Ms. Janice Greene, National Research Council

EWI: Edison Welding Institute, Columbus (January 22-23)
- Dr. Harold W. Paxton (Chairman), Carnegie Mellon University
- Dr. Gene Goodwin, Oak Ridge National Laboratories
- Ms. Janice Greene, National Research Council

AITRC: Applied Information Technologies Research Center, Columbus (January 24)
- Dr. George K. Hutchinson, University of Wisconsin at Milwaukee
- Dr. Dean E. McCumber, AT&T Bell Laboratories
- Ms. Janice Greene, National Research Council

EISC: Edison Industrial Systems Center, Toledo (January 25-26)
- Mr. Leonard A. Harvey, State of West Virginia
- Dr. Dean E. McCumber, AT&T Bell Laboratories
- Ms. Janice Greene, National Research Council

EBTC: Edison BioTechnology Center, Cleveland (January 30-31)
- Ms. Dorothy K. Holmes, Putnam, Hayes & Bartlett
- Dr. Mark L. Pearson, E.I. du Pont de Nemours & Co.
- Dr. Stephen Rattien, National Research Council
- Ms. Janice Greene, National Research Council

CAMP: Cleveland Advanced Manufacturing Program, Cleveland (January 31-February 1)
- Dr. George K. Hutchinson, University of Wisconsin at Milwaukee
- Mr. Leonard A. Harvey, State of West Virginia
- Dr. Stephen Rattien, National Research Council
- Ms. Janice Greene, National Research Council

IAMS: Institute of Advanced Manufacturing Sciences, Cincinnati (February 12-13)
- Dr. Harold W. Paxton (Chairman), Carnegie Mellon University
- Dr. Dean E. McCumber, AT&T Bell Laboratories
- Dr. Stephen Rattien, National Research Council
- Ms. Janice Greene, National Research Council

EABC: Edison Animal Biotechnology Center, Athens (February 20-21)
- Mr. H. Graham Jones, New York State Science & Technology Foundation
- Dr. Mark L. Pearson, E.I. du Pont de Nemours & Co.
- Dr. Caird Rexroad, U.S. Department of Agriculture
- Ms. Janice Greene, National Research Council

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