1994 SIAM Forum Final Report

Mathematics in Industry: The Job Market of the Future

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Paul Davis
December 10, 1994

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Foreword

The SIAM Forum was conceived by Ed Block, SIAM's Managing Director, emeritus, to promote exchange within the applied mathematics community on important issues and to inform and energize it.

The aim of the 1994 Forum was a broad view of employment and careers in industry. That perspective complemented SIAM's Mathematics in Industry project, whose goal is improving the match between graduate education in mathematics and careers in industry. The Forum was held on July 23, 1994, in San Diego, CA, preceding the SIAM Annual Meeting.

The panelists and speakers at the 1994 Forum deserve the thanks of the entire community for their thoughtful contributions to this event. They provided a wealth of information and insight to the Forum participants and, through this report, to the entire community. Their participation in the Forum and the preparation of this report was generously supported by a grant from the Department of Energy that was administered by Fred Howes.

The 1994 Forum was organized by Ed Block (SIAM), Paul Davis (Worcester Polytechnic Institute), Avner Friedman (University of Minnesota), Bill Kolata (SIAM), Scott Markel (David Sarnoff Research Center), and Jim Phillips (Boeing Computer Services). Bill Kolata, Carol Deguilio, and Diana Pierce of the SIAM staff played especially important roles in organizing and supporting the Forum.

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* The Mathematics in Industry project is supported by grants from the National Science Foundation and the National Security Agency.

Overview of the Forum

The 1994 SIAM Forum examined applied mathematics in industry with a particular focus on the ingredients for a successful career. The presentations were a mix of panel discussions and individual speakers.

In their presentations and discussions, members of four different panels explored

- the experiences of recent graduates whose first job was in industry,
- the hiring process from the point of view of managers,
- the place of mathematics and of mathematicians in smaller firms,
- the insights of industrial applied mathematicians whose terminal degree is not in mathematics.

Another view of careers in business, industry, and government was provided by a presentation of preliminary data from SIAM's Mathematics in Industry (MII)* project. Finally, techniques for building bridges from academia to industry were described by several experienced speakers.

In spite of the diverse backgrounds of the Forum's panelists and speakers, the central ideas they presented were strikingly similar. These common themes are outlined in the sections that follow. The Forum program is appended to this report.

Succeeding in industry requires communicating effectively (reading, writing, speaking, and listening), being a problem solver, and coupling depth in one area of mathematics with broad interests inside and outside of mathematics that are relevant to corporate needs. Flexibility, a good attitude, and the ability to work in a team are important.

Hiring decisions hinge on these factors as well as on a candidate's potential for growth within the organization. In approaching a company, candidates should exhibit genuine flexibility (enthusiasm for and experience with real-world problem solving, interdisciplinary background, etc.), excellent communication skills, and knowledge of the organization and its mission.

Recent hires contacted in SIAM's MII study often found their jobs on their own. Networking contacts — typically, professors and friends — were often helpful, and co-op or similar experience was very valuable.

Both the comments of speakers and formal surveys in the MII study demonstrate that computational skills are essential. The MII study also found that skills in modeling, numerical methods, statistics, probability, differential equations, and operations research were important to varying degrees.

Mathematical contributions in industry are almost always made in the context of another field. The value of such work is measured by its impact on the organization.

Solutions to problems must be given in terms understood by the customer, whether internal or external. Often, partial solutions to problems must be developed quickly with incomplete knowledge.

Few problems are identified as specifically mathematical, but organizations do sometimes recognize that they have problems to which mathematicians can contribute. Mathematicians are useful in industry because they can move quickly from problem to problem and because they can penetrate deeply and rationally.

University departments that want to build bridges to industry should form networks built around their own graduates, exploit other contacts within their institution (such as engineering departments with a history of such outreach), and make use of the resources of their institution's development office. Persistence and realistic expectations are essential.

Before departments seek industrial relationships, they should determine their own objectives and needs as well as those of the potential industrial partner. They should be prepared to build the relationship from the bottom up. Successful programs will have programmatic substance, offer recognized value to both participating organizations, be built on shared respect for the expertise and goals of each partner, and evaluate regularly the activities and accomplishments of the partnership.

Preparing for Industrial Employment

Although the Forum was not focused specifically on finding a job in industry, the comments of many of the panelists were sprinkled with ideas that can help a mathematician, particularly a graduate student, who is looking for such a position. The list of fundamental steps to an industrial job is short: network, educate yourself about your potential employer, and have the right attitude and skills. Acquire co-op or other industrial experiences if you can.

Experience in industry before or during graduate school accumulates vital evidence of interest in real-world problem solving. That experience could be acquired through summer jobs, cooperative employment programs, internships, postdocs, an industrial project, etc.

Courses and similar experience (including a minor or a second degree) in a discipline outside of mathematics is proof of broad scientific interest and flexibility. Evidence of ability to learn another discipline and to communicate with its practitioners is important. Dabbling superficially is not useful.

Much the same can be said of computational sophistication. Computational skills are essential; ideally, be able to present evidence of having used computation to solve realistic problems.

Practice all forms of communication — reading, writing, speaking, and listening — especially with nonmathematicians. Accumulate evidence of those skills and be prepared to exhibit them naturally in contacts with a potential employer.

A good job application will show proof of the desired traits — communication skills, breadth and depth in mathematics, interdisciplinary experience, commitment to solving real-world problems, etc. — as well as a good understanding of the potential employer's needs and mission. The latter can come from research using the resources of a university placement office.

Letters of application must be targeted to a specific potential employer. All contacts with the employer should demonstrate the essential personal and professional characteristics described earlier. In addition, those contacts should exhibit less tangible qualities, such as the potential for technical and professional growth.

Peter Castro, who manages an applied mathematics group in Eastman Kodak Company, agreed with many other speakers when he urged that job seekers "use the university career office for information that will help target your application to the people and needs" at the place where you are applying. Jim Phillips spoke despairingly of receiving mass produced, university-oriented letters telling of the applicants' desires to continue academic research in the Mathematics and Engineering Analysis group he manages at Boeing Computer Services.

Castro emphasized that "your application must stand out from many competitors — other mathematicians, operations researchers, physicists, engineers, MBAs, ... How can you make it stand out? Write an articulate cover letter that is targeted at my business. Show breadth as well as depth. Demonstrate real interest in and eagerness for applications. Show that you are flexible.

"Don't write, 'I work in right semi-quavers. What kind of jobs do you have?' And wear a tie if you visit. You will visit at least one upper level manager.

"Your resume should exhibit your modeling skills, your computational skills, your communication skills, and your experience in and enthusiasm for solving real problems. It should also be proof of your efforts to learn about the company to which you are applying."

Karen Dunlap found her job at Bellcore by applying directly to the personnel office, an "unheard of" occurrence. She attributes this singular event to having completed a thesis that included the successful implementation in industry of her doctoral work.

Randy Doyle found his way into the Lockheed Advanced Development Company by a more common route, networking. Piles of resumes had gone unanswered until his major professor contacted a friend who was a group leader at Lockheed. A few days later, Doyle's future supervisor called looking for his resume.

What did he learn from the experience? He "should have used an engineering

The Transition to the First Job

fellowship or a similar summer work experience to get into industry instead of washing dishes." Developing better contacts with engineering faculty while he was in school would have helped, too.

Dulce Ponceleon's employer, Apple Computer, Inc., offers a formal mentoring program for new employees. Those mentors form yet another network worth nurturing.

The David Sarnoff Research Laboratories, the large communications research contractor in which Scott Markel works, will try to create a slot if an individual "has skills that can expand business in a new direction." Since Sarnoff finds many of these people through networks, Markel warns, "Don't wait for a job posting."

Chuck Wilson, who was trained as a mechanical engineer but works as an applied mathematician for S-Cubed Corporation, a government contractor, offered parallel advice. "Be flexible. Talk to anybody close to what you know." Wilson, who found his first job through his major professor, felt he had an edge in the engineering job market because of the extra mathematics he knew.

Wilson also offered some pointed advice to mathematics faculty, who do their students "no favor if you say, 'Look only for a job in mathematics or applied mathematics.' Don't discourage your students' apparent loss of identity as mathematicians. Be flexible, too!"

What kinds of positions are new graduates hired to fill? How do they make the transition from graduate school to the first job?

Polly Moore notes that her employer, the biotechnology firm Genentech, Inc., seldom says, "Hire mathematicians." But it might advertise for scientific programmers. Given such a need, she would "welcome a resume from a mathematician with experience in biology and computing" but not one that sends the message "I only do perturbation theory." Successful applicants need to show evidence of "clear thinking, communication skills, and the ability to come up with solutions to real-world problems."

New hires should expect only a brief transition period from university to industry. Bill Browning does anticipate a transition period when he hires new graduates into his contract and consulting firm, Applied Mathematics, Inc. They must shift from students who complete set problems for a grade to independent scientists who work with customers on open-ended problems. But he is typical in offering "less transition time now than years ago." He is leery of mathematicians who want time to "analyze the tensile strength of a problem. Is it too hard to solve or too trivial to bother?"

Castro adds, "Now we can't wait while someone turns into an industrial mathematician."

Markel concurs, noting that a transition period that was once six to twelve months is now just two months or less in his consulting laboratory. The lab "wouldn't hire me now" because of the computational skills he lacked then and because it can no longer provide a long transition period.

Succeeding in Industry

According to the Forum's panelists, succeeding in industry hinges on a few primary skills: communicate effectively (read, write, speak, and listen), be a problem solver, couple depth in one area of mathematics with broad interests relevant to corporate needs.

Combining depth and breadth was often captured in a single word, flexibility, but flexibility comes in many forms.

In Bill Browning's contract and consulting firm, he likes to see a good attitude in a "low maintenance employee." Tom Haigh of Secure Computing Corporation likes colleagues in the computer security business who are "self-directed. They can take concepts and general ideas and run - but keep in touch" so that senior staff can spend their time leading, not involved with project details.

Besides technical expertise, Rolf Carlson of Spring Creek Technologies noted that entrepreneurs like him "need to know how to capitalize on opportunities." More bluntly,

Tom Haigh declared that mathematicians need "to be willing to get dirty." They have to regard a problem as "interesting because a customer cares or because a team of six co-workers is waiting for your results."

Carlson emphasized an entrepreneur's need to communicate ideas to the people with money to invest in them. To Carlson's art of "championing your ideas orally and in writing," Tom Haigh added the communication skill of listening, both to customers and to team members.

Bob Hall's work with Science Applications International, a large government contractor, has taught him to liken an applied mathematician communicating with a customer to an auto mechanic who has finished a repair job. "The customers don't want a lecture. They want to drive!" Indeed, presenting too much mathematics and not enough solution may seem to be a smoke screen, suggesting "to the customer," Hall cautions, "that you didn't really solve the problem."

Hall has also observed that many customers don't know what they want until they see a prototype. In addition, he can't charge for one percent accuracy when two percent will do. Those constraints demand that he "use engineering criteria to choose from among a variety of mathematical tools."

Working in a similar environment, Price Kagey of Titan Corporation added computing and software tools to the list of ingredients for success.

Speaking as a chemistry Ph.D. in the San Diego State University mathematics department, Peter Salamon commented that in an interdisciplinary environment "team working and communication skills are crucial. There are not enough of these in academic mathematicians."

Frank Tobin's perspective from SmithKline Beecham Pharmaceuticals was similar: the keys to success are "flexibility, willingness to learn new areas of science, communication skills, and patience working with clients and management." He added the need to be "an entrepreneur, selling yourself and mathematics."

Castro thought that "attitude — the willingness to be flexible and branch out" was key in the chemical industry too. Among the many areas into which a mathematician might branch — chemistry, physics, and so on — he particularly emphasized computation.

In their industrial environments, he and his mathematically trained colleagues must be "team players, working with individuals from other departments on a daily basis. We have to work with them to find the right problem, uncover something new, put it into a form others can use, and help them use it. We write the report and help with implementation."

Beyond specialized knowledge in scientific computation, Bill Coughran of AT&T Bell Laboratories explained the need for breadth and communication skills in a computing group within the telecommunications industry. "We need background knowledge in the physical sciences and interest or experience in solving real problems. Our people must also be able to interact with other members of our group and with computer scientists, physical scientists, and engineers."

Lonnie Hudgins, who has survived several rounds of layoffs at Northrup-Electronics System Division, a major defense contractor, has his own measure of success. "Be able to balance the company's needs, the need for funding for your own work, and your personal research interests."

He has three levels of strategies for achieving that success. At the lowest and most vulnerable level, "solve the problems assigned, providing accurate, timely answers within budget and other constraints." To survive a bit longer, "find out the company's goals. Don't wait for an assignment. Formulate problems in an identified context (knock on doors!) so that the dollars you need can be found."

Finally, to truly prepare for the long haul, "determine what your company's goals ought to be. Don't take everyone's word for it. Influence product development, strategies, spending priorities and, ultimately, long range research plans." At that level, "you can combine the need for funding with your love of science."

Flexibility and Attitude

The notions of flexibility and the right attitude also had a more personal dimension for many of the panelists.

Cleve Moler of The MathWorks, Inc., who has wide experience in academia as well as in the computer industry, pinpointed the need for flexibility when he observed that most of the younger industrial applied mathematicians who had spoken were not working at the jobs for which they were originally hired. "Flexibility is the hallmark of an applied mathematician," he added.

Ponceleon was hired into the computer industry by a manager with a technical background. By the time she reported for work, he had been replaced by a non-technical manager with no interest in the project for which she had been hired. She had to establish her value on her own.

Doyle moved from graduate school in the wide open spaces of Montana to a "disgusting, dirty" aerospace factory in an urban location. His revulsion diminished when he realized that the factory was the place where "they built the things that paid the bills."

Doyle was hired to work on an artificial intelligence project. Two months later, the project evaporated and he was "thrown to the wolves." He shortly found himself drawing on his undergraduate physics to adapt an acoustics computer code for another application.

Some of the Forum participants commented on an apparent contradiction: flexibility is important, but usually individuals are hired for specific projects. Markel replied that when the current project was completed in the communications consulting laboratory where he works, flexibility was necessary "to migrate to a new project."

Castro gave this observation a different twist by noting that industrial employers, like his in the chemical industry, want someone who "can do the current problem and the next, too." Doyle believes that a person who "develops interests in solving new problems in new ways will become flexible." Jeff Allen's experiences in the Navy's Control and Ocean Surveillance Center had convinced him that "interest in the data will push you to new problems."

Computation

Castro put the importance of computation bluntly. "The set of real problems you can solve with paper and pencil has measure zero."

Coughran elaborated on the characteristics needed in a member of a scientific computing group within the communications industry. "We seek a deep knowledge of a subdomain of numerical analysis, a knowledge of scientific computing and of computer science topics like memory hierarchies."

Hall explained that the problems in his firm's government contract work "may require more than the existing code can do, because the geometry is too complex. It's also why the Navy pays us, not a university." Other speakers suggested that in different settings, prior experience with commercial codes can be useful.

Karen Dunlap, who moved from a thesis problem in the textile industry to employment in the telecommunications industry, touched on flexibility in the context of computing. She found that no one specific programming course in school was essential "because I am using new languages now." Instead, she learned that it was important to be able to master new languages quickly in order to use whatever was most appropriate to a specific project.

Phil Smith of WindWard Technologies, Inc. drew on his experience in the software industry to be completely direct. "No computational skills? Then you are locked out of certain job opportunities. But," he warned, "don't water down your mathematical background" to get those computational skills.

Several sets of statistics from the MII survey of recent graduates working in industry confirm the importance of computing. Nearly 80% of the doctoral graduates indicated that computing was "essential" or "very important" to the work of their group; more than 50% of the masters graduates responded similarly. The doctoral graduates spend on average almost 45% of their time computing; masters graduates spend about 30% of their time.

The Hiring Process

The hiring process is surprisingly uniform across the range of organizations represented at the Forum.

Rich Sincovec described the three main steps of advertising, interviewing and decision making at Oak Ridge National Laboratory. Open positions are announced through display ads in periodicals like *SIAM News*, through nadigest on the Internet, and through various professional networks. Secondary recruiting efforts include career fairs and national meetings of professional societies. His lab does little on-campus recruiting. Instead, candidates are invited to the lab for an interview.

Such a visit typically fills one and one-half or two days. Visiting candidates are interviewed by management and by technical staff of the hiring division. They also present a technical seminar.

The decision to hire is made by the division staff and various managers. His lab's hiring process also includes an ad hoc review panel, a practice not common in other locations.

During the screening process, Sincovec and his people are evaluating the candidate's "professional performance and experience" and potential to contribute "over the long term to many areas." Is there evidence of originality and innovation? Of "potential for growth, for scientific or managerial leadership"? Of "good professional and personal characteristics, good communication and team skills"?

When Phillips is hiring a new member of his aerospace computing group, he asks himself if the candidate offers "something complementary to the existing skill base in a specialty of interest? Are the credentials solid? Is there real interest in applied industrial work?"

Milo Dorr of Lawrence Livermore National Laboratory identified several trends among the national laboratories that affect their hiring. One is reorganization and mission redefinition, which "offer a challenge to long range planning but also open up opportunities in new areas like technology transfer."

Other trends listed by Dorr include increased use of term appointments like postdocs and pressure for quicker returns on investments in research through "end to end applications development." In the latter, "multidisciplinary expertise is essential." Finally, redistribution and decentralization of resources means "less support for traditional disciplinary infrastructure and the expectation to hire from within, if possible."

The Role and Place of Industrial Mathematicians

Although she spoke from her vantage point in the biotechnology industry, Moore captured the dominant view of the industrial mathematician's role. "You must contribute in the context of another field. It's OK to work on problems where the mathematics is not hard but the problem is significant. Your contribution will be measured by its impact on the organization."

Differentiating a mathematician from a computer scientist, Haigh explained that his colleagues in the computer security industry "need mathematical training to do the job we need."

Moore explained that problems come to mathematicians in many forms. An "unusual" few arrive already stated in mathematical form, like one from a molecular modeler asking about a distribution of points on a sphere.

Others are a little looser. For example, a marketing vice president recognized the connection between bonuses and the behavior of the sales force but needed help from Moore to construct a bonus formula that would lead to the desired outcome. A bench scientist wanted help "to explain the equations in the appendix" of a paper to determine if its ideas were useful.

Moore has fielded other questions with unusual twists, such as a call for help understanding "how this software works." This problem turned out not to be a question of deciphering a manual. Instead, the user had uncovered a computational error in a statistical package.

Education and Level

Outreach from Academia to Industry

Moore cites these experiences as examples of a mathematician "building within the company a practice in which you become a collaborator on a wide variety of projects."

In Hall's contracting organization, there are 1,100 divisions, none organized around a single discipline. Instead, each is "near its customers. The people there are what is needed for the customer."

In a similar setting, Kagey likes "applied mathematicians because they are flexible enough to jump in and tackle any problem."

Salamon believes that the place of an applied mathematician is certainly not working alone. He observes that "the ability to look at a problem from the phenomenological end requires a team. Mathematicians can't know everything, but once they learn to think in two different ways, they can communicate with another discipline. And then they can more easily learn other ways to think, the third, the fourth,"

Tobin says simply that the place of industrial mathematicians is as "problem seekers and problem solvers."

The mathematicians in Jim Phillips' large computational sciences group at Boeing Computer Services divide their time between research on new computational methods and consulting to its aircraft, defense, and space companies.

Ponceleon found that being identified as a mathematician within a prominent computer manufacturer left her in a potentially vulnerable position. "I was being viewed as a specialist, not as central to my group. I had to show I could do other things and not get cornered in one role. So I consulted for other groups in the company." That led to her transfer to a group in which her background was more central to its mission.

Smith sees the mathematician's role similarly, as one who is constantly alert for opportunities to contribute to important problems. "Companies don't identify problems as mathematical", but they do have problems that can be addressed by mathematically trained consultants.

Moler's software organization, which "takes little nuggets of mathematics and puts them into software, does not hire (many) mathematicians" but it does hire "mathematical background." In those individuals, the Ph.D. "shows ability to finish a large project."

Among the recent graduates contacted by the MII survey, none work in groups in which mathematics is the majority discipline. Typically, computer science and engineering graduates appear about as often as those with mathematics degrees.

The mathematics used in industry can be very basic. The catch, Moore says, is that "to see which basic mathematics tool to use, you may need more than undergraduate mathematics. The additional years of graduate education provide a thorough grounding in basics."

Doyle was pleased he was a teaching assistant rather than a research assistant in graduate school. Teaching brought him to the point where he "could do calculus very well. Most of my work now is basically calculus."

When the MII survey asked recent graduates about the primary mathematics specialties required by their work, modeling, numerical methods, statistics, probability, and differential equations were mentioned by half or more of the doctoral respondents. More than half of the masters respondents cited modeling, statistics, and probability. Operations research, discrete mathematics, and other areas were mentioned less frequently by both groups.

Avner Friedman of the Institute for Mathematics and Its Applications at the University of Minnesota described the growth of the program in industrial mathematics at Minnesota. He particularly emphasized the need for individual contacts between university faculty and colleagues in industry.

Friedman announced that the University of Minnesota has set up three new positions to start a Minnesota Center for Industrial Mathematics. The new faculty will be appointed

through the Mathematics Department. They will visit industry to identify problems and projects for students. They will also create new courses in mathematical modeling and computation. In addition to supervising students completing internships in industry, they will work closely with other faculty in the Institute of Technology, which includes engineering and sciences. A program leading to a Masters Degree in Industrial and Applied Mathematics has already begun.

Friedman encouraged faculty in the audience by noting that "the program at the University of Minnesota can be emulated elsewhere, provided there are faculty members who are sincerely interested in working with industry and in devoting the time necessary to start the program. On the other hand, the mathematics departments must provide incentives to such faculty, since the start-up process is lengthy, and the results will show only after one or two years.

"Students going through the programs and, in particular, through the internships are much more likely to find jobs in industry. In fact, in various meetings with managers in industry, it was explicitly stated that a successful internship shows that the candidate has the right kind of 'positive attitude' as well as communication skills and the ability to work in teams. All these qualities are essential to successful careers in industry."

Deborah Lockhart of the National Science Foundation described three programs to enhance university-industry collaboration. These are Mathematical Sciences University-Industry Postdoctoral Research Fellowships, Mathematical Sciences

University-Industry Senior Research Fellowships, and Industry-Based Graduate Research Assistantships and Cooperative Fellowships in the Mathematical Sciences. They are described in the program announcement "University-Industry Cooperative Research Programs in the Mathematical Sciences," NSF announcement number NSF94-100. Instructions for retrieving an electronic copy of this announcement can be obtained by sending the message get index to stisserv@nsf.gov.

Judy Cottrell Blantz, Director of Development for the School of Engineering at UC-San Diego, gave an overview from a professional development officer's perspective of the basic steps in building university-industry partnerships.

She began by describing the wide variety of forms of interaction between industry and universities. Some examples include: programs from federal agencies such as NSF and ARPA; university-based centers funded by various industrial corporations having common pre-competitive research needs; state sponsored programs; various industrial affiliate programs; individual faculty grants and contracts; postdoctoral research projects; multifaceted company partnerships; equipment grants; and even endowed chairs.

Graduate fellowship support from industry can offer a cost-effective and mutually beneficial means of research interaction that avoids overhead costs in certain circumstances. In addition, industry can sponsor projects for undergraduate design courses, and it can hire students for summer internships or co-op work. The latter are often important for subsequent employment.

Blantz described the preliminary steps that are key to initiating an industrial relationship. "Before departments seek such industrial relationships, they need to do their homework. What are the department's objectives and needs? Prepare a strategic plan outlining the program priorities, goals, content, strengths, and organization. Business operates this way and will expect no less of a university.

"What are the needs of the target industry? Study the company business, its product development interests, and its manpower and skill requirements.

"At the same time, the department needs to ascertain its own faculty's motivation, its commitment to the program, and its willingness to invest the substantial time required for such efforts. If that inventory of resources passes muster, then the department needs to establish an appropriate organizational structure to manage outreach coordination and services. Is it seeking a center? A group of industrial affiliates? How will it interact with the development office? Who will have primary responsibility for the relationship?"

Blantz explained that the final stages of preparation include development of effective written material for distribution to potential industrial partners and establishment of a data base and tickler system for industrial contacts. The need for written materials is obvious, but she warned, "The importance of persistent follow up is often neglected."

Actually building the relationships involves another set of key steps. Their primary purpose is demonstrating to the company the value of the proposed interactions.

As a first step, Blantz recommends establishing contact with the target industry to identify an "industrial champion." The latter might be a key executive, a project manager, or someone in the human resources or corporate university relations office, particularly if the organization hires a large number of the university's graduates.

If one goal is support from the company for a proposal to a federal agency, involve that organization early and substantively in the proposal process. For example, don't expect more than a pro forma letter of support for a proposal in response to a last minute request.

Establish a mechanism to ensure regular, frequent interactions. The latter can include exchange visits, seminars, workshops, newsletter, and so on. During these interactions, listen carefully. Understand the company's thinking and be open to its needs. "Above all," Blantz urges, "follow up, follow up, follow up!"

She identified a number of roles in these relationships for university development offices. A central corporations and foundations office can coordinate campus-wide corporate interactions within the context of the institution's academic priorities. The professionals there can assist with proposal writing, provide information resources, and coordinate the participation of chancellors, presidents, and provosts. They can also coordinate the development of "executive champions" across the campus and the involvement of foundations.

At the operational level, development offices can help manage many aspects of industry interactions, such as initiation and cultivation of industrial contacts, planning and scheduling of meetings, oversight of follow up activities, preparation of reports and proposals, planning and execution of special events, and coordination of summer internship programs. These offices also offer a single point of contact for industrial inquiries.

Blantz warned of some potential problems in industrial interactions. "There is not much philanthropy involved. Funding for work with universities often comes from the operational budget, not from discretionary budgets. The current contraction of major industries means fewer and more focused goals for research and development.

"A difficult issue in university-industry interaction can be the influence of sales and marketing issues. The university is a customer, so what you buy matters. Sales reps are often involved in proposals, leading to situations with sticky ethics." Another tough area can be "technology transfer issues — ownership versus license and who pays filing costs for patents."

The bottom line in these interactions is stark but predictable. "It takes resources to gain resources."

Blantz identified two influences, one geographic, the other temporal, of which faculty should be aware. Geographically, "locally based industries and divisions are important. These can sometimes open doors to national industries." Temporally, she pointed to the tension "between short-term and long-term research goals."

She concluded by reiterating the key features of fruitful interactions. "Industry-university partnerships can be successful if they are based upon programmatic substance, recognized value to be gained by each institution (accept that industry has a profit motivation!), shared respect for the expertise and goals of each institution, and continuous monitoring and evaluation of activities and results. Think about being a partner, not a recipient!"

Third SIAM Forum on
Industrial and Applied Mathematics

**Mathematics in Industry:
The Job Market of the Future**

Saturday, July 23, 1994

The Holiday Inn on the Bay at the Embarcadero
San Diego, California

* SIAM would like
to thank the
Department of
Energy for its support
in conducting this
forum.

Final Program

8:15 AM	WELCOMING REMARKS Avner Friedman Institute for Mathematics and Its Applications University of Minnesota, Minneapolis
8:30 AM - 10:00 AM	MATHEMATICIANS IN SMALL FIRMS A panel about the practices, opportunities, and experiences of mathematicians working in smaller firms, and in particular the implications of the rapid growth of such firms for the practice of mathematics and the employment of mathematicians outside academia. Chair: Polly Moore Panelists: <i>William J. Browning</i> , Applied Mathematics, Inc., Gales Ferry, CT <i>Rolf Carlson</i> , Spring Creek Technologies, Albuquerque, NM <i>Thomas Haigh</i> , Secure Computing Corporation, Roseville, MN <i>William P. Kamp</i> , Insight Access Group, St. Paul, MN <i>Cleve Moler</i> , The MathWorks Inc., Natick, MA <i>Polly Moore</i> , Genentech, Inc., San Francisco, CA <i>Philip W. Smith</i> , WindWard Technologies, Inc., Houston, TX
10:30 PM - 11:30 AM	NON-MATHEMATICIANS WHO DO MATHEMATICS IN INDUSTRY The practice of mathematics is not the sole realm of mathematicians in industry. How did those without a degree in mathematics end up doing mathematics? What do they do? How did they get their positions? Chair: Frank Tobin Panelists: <i>Robert E. Hall</i> , Science Applications International, San Diego, CA <i>Price Kagey</i> , Titan Corporation, San Diego, CA <i>Charles E. Wilson, Jr.</i> , S-Cubed Corporation, La Jolla, CA <i>Peter Salamon</i> , San Diego State University, San Diego, CA <i>Frank Tobin</i> , SmithKline Beecham Pharmaceuticals R&D, King of Prussia, PA
11:30 AM - 12:00 PM	SIAM MATHEMATICS IN INDUSTRY PROJECT - PRELIMINARY RESULTS The SIAM Mathematics in Industry Project aims to improve the match between graduate education in mathematics and successful careers in business, industry and government. It is assessing the uses of mathematics and the experiences of mathematicians in these settings through telephone interviews with recent graduates and their managers and through site visits.

1:00 PM - 2:00 PM

HIRING IN BUSINESS, INDUSTRY, AND GOVERNMENT: THE MANAGER'S PERSPECTIVE

The speakers will discuss the current needs, practices, and opportunities for mathematicians in industry. Who is getting what kinds of positions and why?

Chair: James Phillips

Panelists:

Peter E. Castro, Eastman Kodak Company, Rochester, NY

W. M. Coughran, Jr., AT&T Bell Laboratories, Murray Hill, NJ

Milo R. Dorr, Lawrence Livermore National Laboratory, Livermore, CA

Jim Phillips, Boeing Computer Services, Seattle, WA

Richard F. Sincovec, Oak Ridge National Laboratory, Oak Ridge, TN

2:15 PM - 3:30 PM

REPORT FROM THE FRONT: EXPERIENCES OF RECENT INDUSTRIAL HIRES

The speakers are mathematicians who have begun working in industry within the last few years. They will discuss their experiences. How did they find their positions? What do they do? How is it like/different from their university training? What problems occur in transition?

Chair: Scott Markel

Panelists:

Jeffery C. Allen, Naval Command, Control & Ocean Surveillance Center, San Diego, CA

Randy R. Doyle, Lockheed Advanced Development Company, Burbank, CA

Karen Dunlap, Bellcore, Piscataway, NJ

Lonnie Hudgins, Northrop-Electronics Systems Division, Hawthorne, CA

Scott Markel, David Sarnoff Research Laboratories, Princeton, NJ

Dulce B. Ponceleon, Apple Computer, Inc.

4:00 PM - 5:30 PM

REACHING FROM ACADEMIA TO INDUSTRY

How do you build bridges between academia and industry? The speakers will discuss techniques and programs that work for building bridges. How to contact local industries; how to use industrial post-docs, how to use summer internships for faculty and students in government labs; how to build alumni/ae networks (advisory panels, newsletter, receptions, etc.); what information sources are typically available at university offices.

Speakers:

Judy Cottrell Blantz, University of California, San Diego, La Jolla, CA

Avner Friedman, Institute for Mathematics and Its Applications, University of Minnesota

Jim Lightbourne, National Science Foundation, Washington, DC

Deborah Lockhart, National Science Foundation, Arlington, VA

6:00 PM

NETWORKING SESSION & DINNER

Personal contacts are key elements in improved linkages between academic and industrial mathematics. This session will be structured to facilitate constructive, practical interaction. Closing remarks by Avner Friedman.

**Organizing
Committee**

I. Edward Block, SIAM Managing Director, emeritus

Paul Davis, Worcester Polytechnic Institute

Avner Friedman, Institute for Mathematics and Its Applications, University of Minnesota

Bill Kolata, SIAM Technical Director

Jim Phillips, Boeing Computer Services, Seattle, WA

Scott Markel, David Sarnoff Research Laboratories, Princeton, NJ

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