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Trip Report: European Team

American Practitioners' Views of Technology Management in European High-technology Organizations

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NATIONAL TECHNLOGICAL UNIVERSITY
MANAGEMENT OF TECHNOLOGY PROGRAM

INTERNATIONAL STUDY MISSION
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Trip Report: European Team

PREFACE

The faculty and staff of the National Technological University's Management of Technology Masters degree program prepared this report based on inputs prepared by the team members who participated in the trip.

Special thanks are extended to Todd A. Watkins of Lehigh University and Bruce Poole of Agilent for writing and editing subsequent drafts of the report. Comments and corrections should be directed to Professor Alden S. Bean, who is responsible for the inevitable errors and omissions that will be found. We hope these will not detract from the spirit of the report, which is that of sharing our insights and observations.

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NATIONAL TECHNLOGICAL UNIVERSITY MANAGEMENT OF TECHNOLOGY PROGRAM

INTERNATIONAL STUDY MISSION MAY 2001

Trip Report: European Team

American Practitioners' Views of Technology Management in European High-Technology Organizations

EXECUTIVE SUMMARY

From May 12 through May 28, 2001, 11 graduate students in the National Technological University's Management of Technology Executive Master's degree program—together with one guest manager and faculty advisor—visited 12 European companies and 5 other industry organizations and were guests of the European Commission in Brussels. The student team sought insights into European Science and Technology policies and management practices. Based on inputs the students provided and compiled and a review and edit by Program faculty and staff, this report describes what students learned on that highly successful trip.

As with previous Study Missions to Japan, Korea, and Europe, our host organization in Europe received us warmly and responded to our questions directly and candidly. These hosts, almost without exception, had studied our questions and shared material—in many cases created specifically for our visits—to address our interests. We had the opportunity to meet both with senior executives, who provided us with a strategic perspective on scientific and technical affairs, and with managers of technical and personnel functions and programs, who shared their experiences about day-to-day management challenges. The entire visit was conducted in an environment of mutual respect and with a keen interest in sharing information and experiences. We feel highly fortunate to have been so well received.

Study Mission team members began their experience as guests of the European Commission in Brussels. The Program provided an introduction to European institutions, the single market, and European Union (EU) regulatory and standardization efforts, with particular focus on EU collaborative research and development (R&D) programs, information technology, and e-commerce. An additional evening session with representatives from Siemens, IWT in Flanders, and the Eureka Secretariat broadened the scope to include related programs beyond the realm of the Commission. This gave us valuable insights into current EU political and economic developments and the broad

European R&D systems as well as the views of European firms on the EU and related programs. We began to appreciate the immense challenges involved, the great strides already made, and the work in progress that will continue in the coming decades as the EU expands. (*See Section 6A for details.*)

Then we began visiting companies and industry organizations across six countries, exploring six key interest areas: First was the **impact of the European business and regulatory environment** on their businesses. Our lasting impression was that the EU now seems taken for granted by most of the hosting organizations. The EU's most important role for the European technology managers generally seemed to be in enabling standardization, which is often critical in high-technology industries, and in fostering labor mobility and infrastructure. On labor mobility in particular, our hosts were generally hopeful that the labor mobility regulations and mutual recognition of technical degrees, coupled with the EU's expected eastward expansion, might help ease tight high-skilled labor markets so that firms could more readily hire technical staff from wherever available. However, we several times heard the comment that, despite the EU, Europeans remain largely unwilling to move across national borders or even to relocate regionally. So too, the Study Mission team noted a continuing strong sense of nationalism wherever we went, although perhaps somewhat diminished compared with our previous European visits. (*See Section 6C, Topic 1, for details.*)

The second topic was in **managing the strategic direction of R&D**. Just as in the US, European companies have a variety of ways of linking R&D investment to their overall business strategy. We saw two key lessons for our companies. First, diversified companies need a strong future vision to guide technology development along the lines of business strategy. This vision must not only be developed, it must also be communicated and utilized in the strategic decision process. As such, Siemens' process was best in class. Second, both large and small companies should be more mindful of disruptive technology in business and technology strategies, investing, at the least, in studying where the risks are. At best, future R&D investments should be strongly influenced by this information. It is a must for any small company and a key to continued success for large companies. Here, we were especially impressed with SAES Getters. (*See Section 6C, Topic 2 for details.*)

The third topic was **managing globally decentralized operations**. Many larger companies maintained a visible R&D presence across Europe and in the US. Some also managed operations in lesser-developed countries. The companies consistently said that they located where the talent pool and/or knowledge base resides. The notable exceptions were generally smaller companies and BASF, which had a strong company value system regarding integrated operations (the *Verbund*) that extended into its R&D activities. On the other hand, most host companies did maintain some distributed R&D operations, but their control of R&D funding appeared more centralized than our US companies. We also note that both Philips and Renault recently became more centralized by relocating into new central R&D facilities—a university-like campus for Philips, and the Technocentre for Renault. The latter was a fascinating place the ISM team afterward endearingly called "matrix organization by architecture." One visit was particularly relevant to this topic: Eurescom is a cooperative organization jointly funded by the European telecommunications industry whose core competence is project management of distributed R&D projects. (*See Section 6C, Topic 3 for details.*)

The fourth topic was **external technology acquisitions through networks, alliances, and acquisitions**. All hosting organizations indicated that, given the pace of technical change, the technological complexity of most of their products, and the scope of their global operations, technology alliances and networks were central to competitive and technical success. Not even the largest firm—Siemens, BASF, or Philips—is capable of leading in every area these days. As in the US, the hosting organizations cooperated with a variety of other institutions, including suppliers, customers, potential competitors, universities, and public research organizations. Most of the organizations used all of these alliances.

One organization, ASML, stood out in the networking area. ASML focuses on its core competencies of systems integration and invests heavily in creating, nurturing, and managing key partnerships with firms offering the world's best competencies in critical complementary areas of imaging, stage mechanics, and materials. ST Microelectronics' acquisition process was equally impressive because it successfully developed a coherent corporate vision and culture and empowered all its employees, despite a continuing series of acquisitions. (*See Section 6C, Topic 4 for details.*)

Fifth, we explored issues in **managing, attracting, and retaining human resources in high-technology firms**. The European firms generally had less difficulty than our US organizations in filling their engineering and scientist positions. For example, because many large, established firms are long-standing, high-quality technical employers in their home regions, they draw large portions of the young technical talent within local geographies toward them. However, although clearly not yet a crisis, the trend seems to be in the same direction as in the US. This situation has driven European firms to work closely with universities around the globe. These university relationships are similar to ours in the US, but collaboration on curricular issues may be broader and richer than in the US. We also witnessed some helpful tools for identifying individual potential early in a technical professional's career. In particular, ST Microelectronics deploys a potential-vs.-contribution matrix, a highly creative metric that allows the company to find and invest in high-potential individuals. An additional impression was that nationalism, cultural differences, and language issues cause the European firms more labor mobility difficulties than we have in the US. Labor mobility a key focus of the EU, so it will be interesting to see the extent to which this issue exists in the future and how the issue evolves as the EU expands eastward. Finally, we note the strategic use of attractive, campus-like environments at both Philips and Renault, in part to facilitate attracting and retaining the best talent from around the world. (*See Section 6C, Topic 5 for details.*)

The final discussion topic was **methods of dealing with disruptive technologies**. We were impressed with the range of techniques and considerable thought our hosting institutions had given to this topic. Mechanisms included those for recognizing opportunities and threats, for managing the risks associated with disruptive changes, and for evaluating and managing the implementation of new disruptive technologies. The most strategically important, overall, seemed to be maintaining a broad range of strong technical alliances and networks to enable quick and effective access to emerging ideas and skill sets, the principal focus of Topic 4. However, we clearly sense that no magic formulas exist for dealing with, developing, marketing, or forecasting disruptive technologies. (*See Section 6C, Topic 5 for details.*)

Finally, beyond those main topics, we returned with **two other significant impressions**. First, we sensed significantly more energy and a more positive outlook about the competitive position of European business in world markets than did the participants in the European NTU Study Mission two years prior. A large fraction of our host institutions were legitimate world leaders, and their strategic visions were not encumbered by attempts to catch up, which the previous group sensed during informal conversations. Similarly, the previous group scored European entrepreneurship as very low on its visit. Our impression was highly different. The Cambridge and Leuven areas were remarkably vibrant entrepreneurial environments, and all hosting firms—from huge Siemens and France Telecom through mid-sized SAES Getters and small Frontier Design, to think tanks such as IMEC—had entrepreneurial processes in place, including support funding for internal incubation and spin-offs. Although overall venture capital and entrepreneurship still seem to lag in the EU compared with the US, to us the gap is clearly and rapidly narrowing.

This trip report provides detailed excerpts from each site visit and a summary of the topics the Study Mission participants and our hosts discussed, as well as additional insights gained during the visit. The students and faculty who participated are grateful to the National Technological University and its corporate sponsors for their financial support of the trip. Additionally, we are indebted to our European host organizations for the precious time and resources they invested on our behalf. We particularly appreciated their openness and trust. We hope all who participated have benefited from their involvement in the 2001 International Study Mission.

MOT Faculty, Staff, and Students in Classes of 2001 and 2002

1. INTRODUCTION

Since 1993, students enrolled in the National Technological University (NTU) Executive Masters of Science Program in the Management of Technology (MOT) have participated in an International Study Mission (ISM). The purpose of these trips, taken in alternate years, is to improve the students' appreciation and understanding of industrial practices and government policies that support technology innovation among the international community.

The Study Mission focused exclusively on Japan in 1993 and 1995. In 1997, Japan was again the primary destination, but a brief and highly productive stop in Korea was added. In 1999, the team consensus was to visit Europe because of the European Union's (EU) gathering momentum of initiatives and the economic recessions in Japan and South Korea. In 2001, interests were clearly divided; after extensive planning sessions with the students, the group decided to divide into European and Asian teams. Preparations began in the fall of 2000; and on May 10, 2001, students, faculty, and NTU staff associates met at Lehigh University in Bethlehem, Pennsylvania, to prepare for the trips. On May 12, 2001, the 2001 ISM teams departed, one leaving for Brussels, the other for Tokyo. The trips ended on May 28.

This report highlights the goals and objectives of the European trip and reports on what the participants learned. It will be distributed to everyone who participated in the ISM and to the many organizations and individuals who helped conduct it. Comments, corrections, and extensions are most welcome.

2. ORGANIZATION OF THE REPORT

Sections 3 through 5 present the principle findings of the members who participated in the European mission. Section 6A gives a summary of the introductory discussions in Brussels, covered in four sessions. These sessions focused on the following:

- The current state of political and economic developments and prospects for growth in the next decade;
- The research and development (R&D) systems in various European countries, including the role of European governments, industry and universities;
- The particular role of the EU in support of R&D, technological innovation, and global economic development; and
- The views of European industrial organizations on EU and related programs.

Section 6B presents a brief profile of each organization visited in Europe, which team members prepared in advance. Section 6C presents a summary of the discussions at each organization, which were based on the suggested topics the team members had also prepared in advance. *(See Appendix B for detailed descriptions of the topics.)* Briefly, these topics included—

- The Strategic Direction of R&D and Management of Technological Innovation;

- Managing Decentralized Operations;
- External Technology Acquisition Through Networks, Alliances, and Acquisitions;
- Managing Human Resources in High-Technology Firms; and
- Dealing With Disruptive Technologies.

The ISM findings were based on the reports of team members during the trip. These findings were discussed among faculty and students in August 2001 at the MOT Program summer residency. The discussions also included observations about the value of the trip and feasibility of future ISMs of this type. This report is the product of the entire ISM group, based on preparatory work, information gathered during lectures and company visits, trip summaries from each student team, and extensive discussions during the past year.

3. STUDY MISSION OBJECTIVES

The purpose of the NTU/MOT 2001 ISM to Europe was to provide an intensive learning experience that would enable the participants to gain first-hand understanding of European technology management practices in a variety of countries and industries, to learn more about European economic cooperation and integration, and to explore some aspects of European history and culture.

To approach the topics from a variety of perspectives, the ISM held meetings with senior executives and managers from a variety of large and small European firms from several different industries in Belgium, England, Germany, France, Italy, and The Netherlands. At these, the participants engaged in discussions about contemporary technology management practices in various industrial and business settings in Europe and the US, as well as about government issues. In this respect, the goals were similar to those of the ISM trips to Europe in 1999, to Japan in 1993 and 1995, and to Japan and Korea in 1997. As in the past, the participants in the 2001 ISM sought an open exchange of views on important issues that technology managers confront as global economic development continues in the next decade.

The ISM teams visited 15 firms and other technology-industry-related organizations, including among others, industrial R&D laboratories, several firms in various sectors of the semiconductor industry, a number of electronics and telecommunications companies, two chemicals and materials firms, an automotive manufacturer, and several entrepreneurial companies with emerging global positions. At the beginning of the ISM trip, the participants met in Brussels with several senior officials at the European Commission as well as the EU liaisons for several European firms and industry organizations. Finally, the participants had the opportunity to explore European history and culture through group tours and housing in historical areas of the host cities.

The 2001 ISM team focused on the following objectives:

- Learn more about the European systems for R&D and technological innovation;

- Understand current economic conditions, as well as the challenges for EU cooperation and integration;
- Become more familiar with the role of the government in several European countries and that of the European Community structure in support of global economic development and technological innovation;
- Initiate professional and social networking with technical managers in European companies; and
- Experience European culture in several countries and explore personal interests through travel and social activities.

4. STUDY MISSION SCHEDULE

May 10–12	Convened at Lehigh University in Bethlehem, PA, for regular MOT Residency activities and ISM briefings.
May 12–13	Departed from New York City for Brussels, Belgium, on the evening of May 12, arriving May 13.
May 14	Met as guests of the European Commission in Brussels, with speakers from the Commission and liaisons from European firms, the Eureka Secretariat, and IWT in Flanders, to provide an overview and discussions about current political and economic developments, R&D systems in Europe, the role of the EU in support of R&D, and the views of European firms on EU and related programs. Sponsored a dinner banquet to thank the European hosts and to meet informally with these and other invited guests.
May 15–16	Visited four organizations in The Netherlands and Belgium: 1. Philips Consumer Electronics, Eindhoven, The Netherlands 2. ASML, Veldhoven, The Netherlands 3. Frontier Design (now Adelante Technologies), Leuven, Belgium 4. IMEC, Leuven, Belgium
May 17	Visited three organizations in Cambridge, England: 1. Cambridge Entrepreneurial Centre, Cambridge, England 2. Cambridge Silicon Radio, Cambridge, England 3. ARM, Cambridge, England Had an informal lunch with Dr. Herman Hauser, CEO of Amadeus Capital Partners and founder of Acorn Computer
May 18	Visited two organizations in Munich, Germany: 1. Siemens Corporate Research and Technology 2. Deutches Museum
May 19–20	Explored European history and culture in the Munich area.
May 21	Visited two organizations elsewhere in Germany: 1. Eurescom, Heidelberg, Germany 2. BASF, Ludwigshafen, Germany

May 22–23	Visited three firms near Paris, France: 1. France Telecom R&D Laboratories, Issy-les-Moulineux, France 2. Renault, Guyancourt, France 3. Saint Gobain, Paris, La Defense, France
May 24	Visited two firms near Milan, Italy: 1. SAES Getters, Lainate, Italy 2. ST Microelectronics, Agrate, Italy
May 25	Departed Milan for return to New York City

5. EUROPEAN STUDY MISSION TEAM

The team members in the 2001 ISM were technical managers in major US industrial firms and government laboratories who are enrolled in an Executive Master's of Science program at NTU, using satellite-based distance learning. The team members were accompanied and led by an MOT faculty member. (See *Study Mission Team* list.)

Faculty Leader:

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Team Members:

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Mr. Thomas Johnson	Department of Energy, Los Alamos, NM
Mr. Rob Kubo	Hewlett-Packard Company, Ft. Collins, CO
Mr. Charles Pluviose	US Army (Civilian), Picatinny Arsenal, NJ
Mr. Bruce Poole	Agilent, San Jose, CA
Mr. Andrew Rodgers	Hewlett-Packard Company, Loveland, CO
Ms. Kristin Schoff	Hewlett-Packard Company, Boise, ID
Mr. Kirk Smith	Agilent, Colorado Springs, CO
Mr. Dan Swanson	Hewlett-Packard Company, Ft. Collins, CO
Mr. George Thompson	IBM, Essex Junction, VT
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6. EUROPEAN STUDY MISSION RESULTS

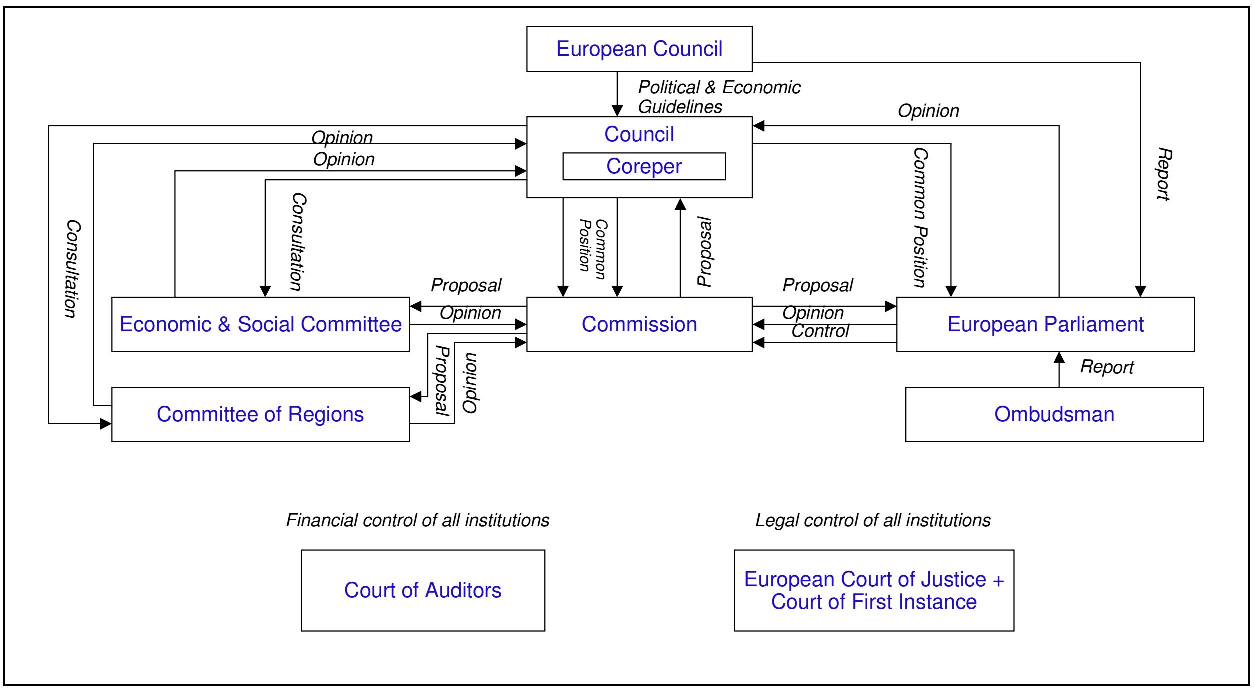
A. The European Union and Related Programs

At the first set of ISM discussions, participants spent a full day with European Commission officials in Brussels, a program arranged in collaboration with Ms. Katrien Colenbie of the Directorate-General Education and Culture. The program provided an introduction to

European institutions, the single market, and EU regulatory and standardization efforts, with a particular focus on EU collaborative R&D programs, information technology, and e-commerce. An additional evening session with representatives from Siemens, IWT in Flanders, and the Eureka Secretariat broadened the scope of discussions to include related programs beyond the realm of the Commission.

Mr. Willem Noë from the Commission's Directorate-General Economic and Financial Affairs began the day with an overview of the EU. Later that evening, Jacky Vanhumbeek of Siemens' European Union Affairs office, supplemented that discussion with a valuable overview of the political and organizational structure of the EU (Figure 1) and the Commission and with an industry lobbyist's perspective on the EU decision-making process.

Figure 1
The Inter-Relation of Community Institutions



Source: Siemens European Union Affairs, Brussels

Mr. Noë's view was that the EU means different things to different people. At one level, the EU is a set of sovereign states joined in super-national institutions pursuing common economic goals. In time it has become an ever-closer union of member states with broader responsibilities and influences. In particular, the original economic core of integration created strong incentives to increase political collaboration and to develop a more unified voice in international affairs. However, the EU cannot do much directly; its independent budget is only 1.27 percent of European GDP. So, more important at another level, the EU is a regulatory framework, with common laws and policies that supercede national law, although those laws must be enacted by legislatures in each nation. With now roughly 80,000 pages of such laws, the EU and related institutions influence all aspects of everyday public life—from food packaging and automobile safety to currency for many member states.

So too, at yet another level, the EU is the legal and administrative framework through which those laws and policies are developed and debated. The European Commission, one of the several European institutional bodies, performs a crucial function. The Commission, which is appointed rather than elected, has the sole power of making legislative proposals. Member states can urge but not force the Commission to pursue common policies at the European level. This is a significant compromise among the states. The idea is that the Commission represents the common European good, whereas member states represent their own interests. But since the member states are sovereign nations, each must enact the laws, and there are no formal sanctions for non-compliance. Thus, the Commission must proceed incrementally, not overstepping the willingness of member states to cooperate. The generations-long process of building the EU has been very largely about trust and confidence building. In what some have termed a "neo-functional" process, policy success in one functional arena spills more than into later policy making in related fields in an expanding cycle of international institution building. EU membership and deepening integration are thus processes with no obvious end.

Other European institutions are pivotal as well. Representatives from each member state are on the Council, and the Council appoints the Commission. The Parliament, the only EU body directly elected at the European level, can suggest amendments and approve budgets, but the Council presides. So the Council of Representatives from sovereign nations holds the real power. Thus, compromise is fundamentally at the center of the EU decision-making process. The process of compromise will get considerably more complex as membership expands eastward, from the current 15 nations to nearly 28. Most immediately, Poland, Hungary, Slovenia, and Estonia should become members before 2004.

Other European institutions include a highly independent Central Bank, which oversees the new euro currency in much the same way Alan Greenspan and the US Federal Reserve shepherd the dollar. Two fairly politically weak bodies, the Committee of Regions and the Economic and Social Committee, can comment on Commission proposals, but they have no formal leverage for change. Finally, the Courts of Auditors and of Justice provide financial and legal controls, respectively, for all the EU institutions.

Why do member states want to integrate? The reasons are historic, economic, and political. The idea of European unity has deep historic roots, as far back as the myth of the unified Roman Empire. Also, the symbolism of being part of Europe is involved. Economically, expanding mutual commercial interdependence provides incentives to cooperate. Moreover, access to a single market of 350 million consumers is highly attractive and can enable otherwise unattainable economies of scale and scope. Additionally, one core function of nation states is to provide common currency. The creation of one common currency in the euro is seen as lifting barriers to trade and economic integration.

Yet currency is a deep political symbol—people identify with their national currency. So, the political gains and compromises also are important. Politically, becoming a member confers international credibility: a nation signs a treaty to publicly bind itself and its future governments to other member states; the nation publicly announces that it will obey and enforce the common EU laws; most importantly, it publicly yields some freedom of sovereign ability.

Other political and economic reasons for membership include increased international bargaining power in trade and other negotiating arenas, including mutual military security. Nations must have economic means to support military security, and they must have security from each other. Indeed, shortly after World War II, the European community actively sought to overcome deep-rooted Franco-German animosities through tying the countries together economically. Political and economic stability is also critical for security, which the EU improves for its members.

The Challenge of European Research and the Fifth Framework Programme

In the second session Stephen Gosden of the Directorate-General for Research, Information, and Communication Unit outlined what many have called the European research paradox. Europe produces about one-third of the world's basic science and technology and has world-leading university and public research systems. Yet, moving the science into the marketplace has not been as successful. The EU lags the US in industrial innovation and competitiveness in key sectors. So, a significant portion of the EU's funds is spent on industrially relevant research.

The EU has supported collaborative R&D programs for decades, bringing together research centers, universities, and companies from different countries. The most important EU R&D program is the five-year Fifth Framework Programme for Research and Technology Development, discussed below. Several thousand projects have been funded, involving tens of thousands of researchers. In drawing up the cycling five-year R&D budgets, the EU considers what can sensibly be funded locally, regionally, nationally, or globally and, through its notion of "subsidiarity," tries to complement rather than displace those other support mechanisms.

Dr. Jacky Vanhumbeek, Vice President (VP) of Joint R&D Projects and Research Funding, European Union Affairs at Siemens, provided a valuable overview of the political and organizational structure of the European Union. He also outlined the Fifth Framework Programme. The following discussion is drawn from his remarks and from information the Commission provided directly (in particular, the multimedia compact disk (CD), *A Knowledge-Based Europe*, European Communities, 1999).

To implement its R&D programs, the EU since 1984 has used an umbrella organizational structure called the Framework Programme for Research and Technological Development. Now in its fifth incarnation, the umbrella policy outlines the European Commission's strategic R&D goals for a five-year period along with the funding allocations in pursuit of those goals. It aims to develop a coherent, truly Europe-wide framework for supporting R&D. In particular, it wants an environment in Europe more conducive to innovation and job creation, including better technology transfer and diffusion of research results, more venture capital, greater protection of intellectual property, and greater mobility and skill development for all levels of the workforce. The Fifth Framework Programme, 1998–2002, covers a wide range of technical (and social and educational) fields and involves a total budget of about €15 Billion, five percent more than the Fourth Framework Programme, 1994—1998. (See Table 1.)

Table 1. EU Fifth Framework Program 1999–2002
(in millions unless otherwise noted)

I. Thematic Programmes. Theme 1: Quality of Life, Management of Living Resources	**€2,413**	• Generic RTD and research infrastructure	188
• Food, Nutrition and Health	290	ii. Energy	1042
• Control of Infectious Diseases	300	• Cleaner Energy Systems, including Renewables	479
• The "Cell Factory"	400	• Economic and Efficient Energy	547
• Environment and Health	160	• Generic RTD	16
• Sustainable Agriculture, Fisheries and Forestry	520		
• The Ageing Population and Disabilities	190	**II: Confirming the International Role of Community Research**	**€475**
• Generic RTD and research infrastructure	553	• Cooperation with third countries	408
		• Training of Researchers	15
Theme 2: User-Friendly Information Society	**3600**	• Coordination	52
• Systems and Services for the Citizen	646		
• New Methods of Work and Electronic Commerce	547	**III: Promotion of Innovation, Encouragement of SMEs**	**363**
• Multimedia Content and Tools	564	• Promotion of Innovation	119
• Essential Technologies and Infrastructures	1363	• Encouraging SME participation	44
• Generic RTD and research infrastructure	480	• Joint Innovation/SME activities	200
Theme 3: Competitive and Sustainable Growth	**2705**	**IV: Improving Human Research Potential**	**1280**
• Innovative Products, Processes, and Organization	731	• Training and Mobility of Researchers	858
• Sustainable Mobility and Intermodality	371	• Access to Research Infrastructures	182
• Land Transport and Marine Technologies	320	• Promoting S/T Excellence	50
• New Perspectives for Aeronautics	700	• Key action: Socio-economic Knowledge Base	165
• Generic RTD and research infrastructure	583	• Development of S/T policies	25
		• Direct Actions (Joint Research Centre)	739
Theme 4: Energy, Environment and Sustainable Development			
i. Environment and Sustainable Development	1083	Total Under EC Treaty	13,700
• Sustainable Management and Quality of water	254		
• Global Change, Climate and Biodiversity	301	EURATOM Treaty: Nuclear Energy and Safety	1260
• Sustainable Marine Ecosystems	170		
• The City of Tomorrow and Cultural Heritage	170	Total Fifth Framework Program	€14.96 B

Source: European Commission, Directorate-General for Research

The structure concentrates R&D activities in areas linked to the EU's main political, economic, and social aims. Priority is on strengthening European competitiveness, increasing employment, and consolidating a high quality of life in Europe. In line with this thinking, the Fifth Framework Programme focused on seven programs: four "thematic" programs and three "horizontal" programs dealing with issues of a general nature. Instead of being divided in the traditional way into scientific fields and disciplines, the multidisciplinary programs are organized around issue areas: industry, health, the environment, energy, and transport. Each covers technological development work, theoretical and basic research, and large-scale demonstration projects. To foster closer cooperation among those implementing the various programs, 17 "External Advisory Groups" serve as liaisons among the key activities. These bring together representatives from the scientific community, industry, and the broad spectrum of users of the research. To foster international collaboration and technology transfer, the Framework Programme is also open beyond the 15 member states to include 16 "associated states" under the same participation conditions. These 16 include the 11 states that have applied to join the EU, together with Iceland, Norway, Liechtenstein, Switzerland, and Israel.

The European Commission does not undertake R&D, except at the Joint Research Center. Rather, the funds support companies and other private and public research organizations. The Commission issues calls for proposals within the goals of the various thematic and horizontal programs and selects grantees on scientific and technical quality and socio-economic impact. Consistent with the EU's integration mission, the most fundamental requirement for participation is that nearly all projects must involve at least two independent organizations from two different member states or one member state and an associate country. The Commission has no national quotas, although considerable emphasis is placed on expanding the capabilities and research infrastructures of the less developed EU regions and also of small- and medium-sized firms.

Mr. Gosden and Mr. Vanhumbeek believe the EU initiatives have helped make more venture capital available—as exemplified by the very healthy high-technology entrepreneurial environment around Cambridge, England—and have improved European competitiveness, particularly in biotechnology, information technologies, telecommunications, and semiconductors. When these EU programs began in the mid-1980s, European IT, telecommunication, and semiconductor firms barely made the top 20 worldwide in their industries. Today, firms such as Nokia, ASML, and ST Microelectronics lead in many market segments. The EU has also succeeded in increasing collaboration among industry across national borders (which is consistent with its mission of economic integration) and also collaboration of industry and academia, which has improved the flow of Europe's leading-edge science into the marketplace.

The Case of E-Commerce in Europe

Mr. Paul Timmers of the Directorate-General for Information Society presented a specific case example of Europe's progress in e-commerce. He asked whether there is continued confidence in this digital economy, given the "dot.com" crash. Mr. Timmers argued that there was confidence: no drop off in confidence is evident in Europe. Information technology is the second largest sector of the economy, 6–10 percent of total business. Moreover, although the absolute levels remain below those in the US, pre-initial public offering (IPO) venture capital investment in Europe has been growing well, and it was fairly steady from October 2000 to the ISM visit in May 2001. Particularly interesting is wireless mobile telecommunications. European telecommunications companies are now heavily indebted because of all of the investments in wireless technologies and infrastructure, and cellular phone use is far higher in most of the EU than in the US, even in lesser-developed EU member countries such as Portugal and Greece. There has also been rapid digital TV growth compared with the US. This continuing stream of high-technology and wireless investments represents a steady confidence and holds much promise.

Internet access is growing rapidly, but it remains somewhat below that in the US. In 2000, 28.4 percent of the EU population were Internet users. In the US, more than 50 percent were users. However, Mr. Timmers believes that more recent data in the US reflects a decrease in Internet use. The picture remains quite promising in Europe. In particular, (ISDN penetration is much higher in Europe than in the US (15.8 percent vs. 1.2 percent) and cable Internet service is rising and higher in the EU as well (7.8 percent vs. 5.4 percent). Encouraging too, small company interconnectivity is now at 70 percent, and half have their own websites. In fact, one-quarter of them are actually buying and selling on the Internet. Similarly, 80 percent of schools are connected to the Internet. However, despite the connectivity, business-to-consumer on-line commerce is still fairly limited, as it is in the US.

So, the Commission has put together a 4-year, $550 million (US) "e-Work and e-Commerce" R&D program to focus on technological, educational and legal development in three challenge areas:

- Cheaper, faster, secure Internet (e.g., interoperability, unbundling local loop services, improving network security, encryption standards, targeting computer-crime, and increasing trust and confidence);
- Investing in People and Skills (E-Skills Relate to 3.7 million Jobs)
- Stimulating the use of the Internet (e.g., new forms of work, e-government, expanding markets, applications and content, developing intelligent agents, clarifying and integrating legal issues such as intellectual property and e-contracts).

Commission members believe the 200 pan-European projects and more than 1000 participating organizations make this one of the largest sets of digital economy applications projects in the world. In fact, information technologies make up the largest part of the planned Sixth Framework Program, 2002–2006.

The EU Regulatory Environment & Standardization: A New Approach

In the final session at the Commission, Evangelos Vardakas of the Directorate-General Enterprise explained the EU's role in standards setting for the high-technology field, and its plans for the future. First, what is a standard? Mr. Vardakas explained that no single, simple definition captures the broad uses of the term. Standards are mostly unseen specifications, regulations, and protocols that ensure things work properly, interactively, and responsibly. In much of the world, standards mean "rules of art." Although they are often critical to have because they improve the functioning of markets, standards can be unpopular because the process by which they are established requires building consensus, often among competing interests. Informal norms may exist, but Mr. Vardakas focused his remarks on formal and ethical standards. The most visible standard to the public is the "CE" mark on products that conform to EU standards, but other standards may involve everything from electronic signatures, interoperability among smart cards, and the mutual recognition of credentials like graduate degrees, to workplace and traffic safety standards.

EU standard policies are a by-product of the movement toward a single integrated EU market. Standards can support such integration through, for example, the harmonization of technical legislation and common reference methods for sampling and analysis. No European standardization program has existed before as such, and the EU's new preference is that public authorities do not define the standards, thus permitting private participants in free markets to cooperatively decide and self-regulate. Indeed, although more than 20 major areas of products or risks are already covered in a corpus of about 7000 standards identical in all EU member states, fewer than 30 percent of European standards have a relation to EU legislation. Rather, the EU recognizes a limited number of independent European standardization bodies. The EU also has a clear policy preference for international standardization, even though decisions are taken collaboratively on the basis of national positions and rely on independent national implementation. So, more than 30 percent of European standards are identical to international ones.

This new approach has resulted in very satisfactory coordination with international standardization bodies, increased transparency in the standards setting processes, the expected participation of nearly 30 European countries in the European standardization system, and other regions moving to more flexible and open standardization processes too.

Other Related, Non-EU, Programs
After discussions with Jacky Vanhumbeek, the May 14 evening session continued with Mr. Leo Van de Loock, Executive Office of IWT in Flanders, who explained the Flanders economy and the role of IWT. IWT is a public agency established in 1991 by the Flemish government and has a budget of approximately €150 million for the promotion of science and technological innovation. Flanders is a Dutch-speaking state in Belgium's federalist structure and has about 55 percent of Belgium's 10 million population and 61 percent of its gross domestic product (GDP). Flanders' per-capita GDP puts it in the top 5 percent of Europe's 77 regions.

A significant part of the Flanders economy is in technology-intensive industries. These include regional strengths in chemical industries in and around Antwerp, automotive industries through the Brussels-Ghent corridor, microelectronics in Leuven, and an emerging biotechnology locus near Ghent. Flanders also hosts more than 2200 firms with more than 60,000 employees at $5 billion **(US)** in value-adding activities in information and communication technologies. Many of these are multinationals such as Siemens, Philips, and Alcatel, but with an increasingly large indigenous group of niche players such as ICOS in inspection systems; Ubizen in security, LHSP in speech technologies; and Barco, Xeion, and Agfa, all in graphics. So too, Flanders hosts Europe's largest independent microelectronics research center, IMEC, in Leuven. Altogether, this information and communications technology (ICT) sector represents more than 25 percent of the R&D investments in the Flemish economy. Overall, the R&D expenditures by private companies are about 1.5 percent of GDP, which compares favorably with the 1.2 percent in the EU as a whole.

IWT offers financial support for selected R&D projects in firms, research centers, research in universities, and regional collaborative R&D networks. IWT also provides some direct services as liaison to the European Commission's Framework Programme, and assists with intellectual property and research and management tools. Funded proposals are selected on their originality and creativity, the level of technological/scientific risk, the expertise of the participants, the quality of the cooperation, the financial capabilities of the participants, and the feasibility of the plan. Projects must have significant strategic value to the participants and large, but longer range, commercial potential relative to the investment. Priority is given to projects with broader social and economic benefits, through potential diffusion of knowledge, positive synergies with the economy of Flanders, and/or contributions to sustainable development. Some preference is also given to small- and medium-sized enterprises (<200 employees), where the added value of Flanders' support may be highest. About 14 percent of IWT funding has gone to these smaller firms, 44 percent to large firms, 24 percent to universities and polytechnics, and the remaining 17 percent to research institutes. The largest share of that last goes to IMEC. (See discussion of IMEC in the site visit section.)

B. Profiles of Organizations Visited

After the Brussels programs, the ISM team began to visit company sites. Under the supervision of Dr. Todd A. Watkins from the College of Business and Economics at Lehigh University, the team visited 12 companies and 3 other technology-industry-related organizations: the IMEC microelectronics research facilities, the Cambridge Entrepreneurial Centre, and Eurescom, the European telecommunications industry's joint research organization. The team had prepared six topics in advance for discussion *(see below and Appendix B)* and forwarded them to each company. During the ISM visits, discussion focused on topics the host companies had chosen from among the six. The team also pursued emerging issues of common interest during the visits. This report does not aim to convey all that was learned about these 15 organizations during the ISM visits, but it is worthwhile to present a brief profile of each company before reporting the results of the discussions.

The European team visited the following companies and organizations, listed here in alphabetical order.

Companies

- ARM, Cambridge, England
- ASML, Veldhoven, The Netherlands
- BASF, Ludwigshafen, Germany
- Cambridge Silicon Radio, Cambridge, England
- France Telecom R&D Laboratories, Issy-les-Moulineux, France
- Frontier Design, Leuven, Belgium (recently renamed Adelante Technologies)
- Philips Consumer Electronics, Eindhoven, The Netherlands
- Renault Technocentre, Guyancourt, France
- SAES Getters, Lainate, Italy
- Saint Gobain, Paris, La Defense, France
- Siemens Corporate Research and Technology, Munich, Germany
- ST Microelectronics, Agrate, Italy

Other Organizations

- Cambridge Entrepreneurial Centre, Cambridge, England
- Eurescom, Heidelberg, Germany
- IMEC, Leuven, Belgium

Brief profiles of each follow, in the order in which we visited.

Philips Consumer Electronics, Eindhoven, The Netherlands, *www.philips.com*

Royal Philips Electronics is eighth on *Fortune Magazine*'s list of global electronics corporations. The company, founded in 1891, is active in about 60 businesses—varying from consumer electronics to domestic appliances, components, and medical systems, and from security systems to semiconductors. It is a world leader in analog and digital technologies for television and displays, wireless communications, speech recognition, video compression, storage and optical products, as well as the underlying semiconductor technology. For example, Philips Semiconductor had 70-percent market share in analog television (TV) chips. Philips sold €37.9 billion in 2000 and employs 219,400 employees in more than 60 countries. R&D activities are organized in three layers at Philips: central corporate R&D laboratories, in-house contract applied/development, and business unit product development. All are done in house. R&D productivity is evident from more than 60,000 patents issued to Philips.

The Study Mission hosts:

- Dr. Jan Lohstroh, Senior VP and General Manager, Advanced Systems and Applications Laboratories
- Rob De Vaan, Manager New Business, Advanced Systems and Applications Laboratories

ASML, Veldhoven, The Netherlands, *www.asml.com*

ASML, a supplier of equipment to the semiconductor industry, is a global company located in the Netherlands, Tempe, AZ, Korea, and Taiwan. It designs, develops, markets, and services photolithography (pl) systems (steppers and scanners) to turn silicon into integrated circuits (ICs). The company was founded in 1984 as a joint venture between Phillips and ASMI, and it incorporated in 1994. With its recent acquisition of the Silicon Valley Group (SVG), ASML in 2001 is number one worldwide in the lithography market. Phillips now holds less than 7 percent of the company. It had more than $2.1 billion (US) in worldwide revenue in FY 2000, 28 percent of which is in the US. Revenue growth in the same year was more than 82 percent. ASML has sales and service worldwide and has 7500 employees, more than 50 percent of whom are employed in the US.

The Study Mission hosts:

- Dr. Rob Verstraelen, Market Analyst, Strategic Business Development
- Jan Hoefnagels, Strategic Business Development

Frontier Design (Adelante Technologies), Leuven, Belgium, *www.adelantetechnologies.com*

When the ISM team visited Frontier Design, it was a small but international company active in signal processing, high-level application-specific integrated circuit (ASIC) design and the development of advanced electronic design automation (EDA) tools. Frontier employs 50 people, and does C-based architectural design, designing hardware and developing software design tools. Frontier particularly focuses on design methodologies, design services, and intellectual property (IP) core development, including the leading-edge forward error correction algorithm, *Turbo Coding*. In June 2001, shortly after the ISM visit, Adelante Technologies resulted from a merger between the Digital Signal Processing (DSP) division of Philips Semiconductors and Frontier Design.

The Study Mission hosts:

- Dr. Herman Beke, Managing Director (now Chief Operating Officer, Adelante)
- Mark A.J. Bloemendaal, Business Development Manager, Europe

IMEC, Leuven, Belgium, *www.imec.be*

IMEC today is the largest independent microelectronics research and development center in Europe. Founded by the Flemish Government in 1984, IMEC is a think tank working on research 3 to 10 years away from commercialization. With a budget above €120 million annually, IMEC employs more than 1100, mostly scientists and engineers, including 270 seconded from many of its 518 industry partners. The partnership list reads like a who's who of leading-edge R&D organizations worldwide, including Texas Instruments, IBM, Hewlett Packard, Lucent, Agilent, Sematech, Samsung, NTT, ST Microelectronics, Philips, Ericsson, and many others. In addition to core funding from the Flemish authorities, IMEC gets significant payments for contract research. In 2000 the total income from contract research rose by almost 66 percent to €70.5 million in 2000. Of this contract R&D, 43 percent was for international companies, 29 percent for Flemish companies, and the rest for the EU, European Space Agency, and other government agencies. IMEC wants to be a world center of excellence and to support local industry and the economy. As one measure of success, more than 20 companies in the Leuven region have been spun off from IMEC. IMEC closely cooperates with Flemish universities. The company makes some revenue from IP licensing and has several service product offerings, including color filter deposition service, advanced ASIC design, low-cost prototype fabrication, and electrical and physical-chemical measurements and analysis.

The Study Mission hosts:

- Dr. Jan Wauters, Advisor, Strategic Development Unit
- Dr. Jo De Boeck, Principal Researcher, Microsystems, Components and Packaging Division

Cambridge Entrepreneurship Centre, University of Cambridge, England, *www.cec.cam.ac.uk*

One of 10 government-funded entrepreneurship centers at UK universities, the Cambridge Entrepreneurship Centre (CEC) provides teaching and training programs in entrepreneurship-related skills, advice, and guidance for entrepreneurs as they develop business ideas. The organization is based out of the University of Cambridge, with its strong connections to the "Silicon Fen" Cambridge-area high-technology cluster. This enables access to those experienced in setting up and growing knowledge-based businesses. CEC also has a technology transfer office that provides advice and guidance on IP, contracts, and licensing issues. It also facilitates the Cambridge University Entrepreneurs

(CUE), which organizes "£50K" and "£1K" business plan competitions, supports internship programs for students wishing to work in start-up ventures during vacations, and facilitates the University Challenge Fund (UCF), which manages a £4 million seed fund for University spin-out businesses and offers small-scale investments. CEC has eight so-called "founder members," including Microsoft, Amadeus Capital Partners, Barclays, Cazenove, Eversheds, KPMG, NIF Ventures, and The Technology Partnership. The founder members provide financing and are also actively involved in the work of the center, providing support and advice to CEC and the start-up companies.

The Study Mission host:

John Snyder, Director, Business Support Team

Cambridge Silicon Radio, Cambridge, England, ***www.csr.com***

Cambridge Silicon Radio (CSR) was founded in 1998 to develop single-chip radio devices, and is a world leader in wireless networking chips. Its devices support wireless data and voice communications among a wide range of products, focused initially on the 2.4-GHz Bluetooth™ personal area networking standard. CSR chips are now in more than 50 percent of all qualified Bluetooth-enabled product designs worldwide. The company is three years old, but the core team has been together for more than 10 years—the founders coming from the design consultancy Cambridge Consultants, where they developed application-specific silicon for clients in telecommunications, industrial, automotive, and healthcare industries, including the world's first single-chip CMOS radio in 1996. CSR is privately held, with significant venture capital and corporate financing.

The Study Mission host:

Glen Collinson, Marketing Director and Co-Founder

Advanced RISC Machines, Cambridge, England, ***www.arm.com***

Advanced RISC Machines (ARM) is the world's leading provider of 16/32-bit embedded RISC microprocessor designs. ARM had a 74-percent world market share in embedded RISC processors in products shipped during 2000. Rather than manufacture directly, the company licenses its RISC processors, peripherals, and system-chip designs to most of the world's major electronics companies. Thus, its principal competitive strategy is R&D, which accounts for a large fraction of its 700 total staff. R&D-to-sales ratio in 2000 was 25 percent. ARM's microprocessor cores are widely used as the RISC standard in such markets as cellular phones and other portable communications, hand-held computing, and multimedia digital consumer products such as the Nintendo Game Boy. Indeed, ARM processors are in about 75 percent of all digital cellular phones.

ARM's history begins in 1985 when (Herman Houser's) Acorn Computer Group developed the world's first commercial RISC processor. Then, in 1990, ARM developed from Acorn and Apple Computer's collaborative efforts to create a new microprocessor for the Apple Newton. VLSI Technology became an investor and the first licensee. In 1998, ARM stock was issued on NASDAQ stock exchange. In 2001, with its designs licensed for so many major applications and 56 licensees (including Texas Instruments, Intel, Samsung, and ST Microelectronics), the company claims that its chip designs sell more than any other worldwide. In fact, 122 million units were shipped in the first quarter of 2001 alone. Its revenues are 57 percent from the US, 22 percent from the Far East, and 21 percent from Europe.

The Study Mission host:

John Cornish, Director of Tactical Marketing

Siemens Corporate Research and Technology, Munich, Germany, *www.siemens.com*

Siemens is Europe's oldest and largest electrical/electronics manufacturer and one of Europe's most global companies. Founded in 1847, Siemens employs 460,000 in 190 countries. Its FY 2000 revenue was €78 billion with a net income of €8 billion. Siemens is a decentralized company with markets and products groups that include semiconductors, computers, telecommunications equipment, power generation, automotive components, trains, medical equipment, and lighting. Siemens is number one worldwide in industrial automation and control, with more than €18 billion in sales, and second after IBM in information and communications, with €26 billion. The company claims that 75 percent of its current sales come from products developed within the last 5 years, so R&D is a critical component of its success. Nearly 57,000 employees are engaged in R&D; and R&D expenditures in 2000 were €5.6 billion, 7.1 percent of sales. In 2000 alone, Siemens filed 5280 new patent applications—4100 with the German Patent Office and 870 in the US.

The Study Mission hosts:

- Hartmut Raffler, Vice President, Corporate Technology
- Ernst Schmitter, Senior Director, Corporate Technology
- Dr. Bremd Kolpatzik, Head of Innovation Field, Information and Communications
- Barbara Mayr, Human Resources

The European Institute for Research and Strategic Studies in Telecommunications, Heidelberg, Germany, *www.eurescom.de*

The European Institute for Research and Strategic Studies in Telecommunications (Eurescom), is Europe's leading institute for collaborative R&D in telecommunications. Twenty European network operators established Eurescom in 1991 to undertake research of joint interest. Eurescom works essentially as a collaborative R&D management company, overseeing the resources of its shareholders in collaborative research projects. Decentralized teams of experts from interested shareholders conduct project work in shareholder facilities, but projects are supervised and coordinated by the Eurescom staff. Eurescom has 27 permanent staff workers in Heidelberg, and this core team manages about 50 projects with more than 800 workers engaged, for a total of 300 staff-years on average annually. Eurescom's research activities are focused on five program areas: (1) expanding telecommunications applications and services; (2) interoperability across different networks; (3) optical systems, broadband issues, and the convergence of fixed and mobile networks; (4) network security and service efficiency; (5) new market evaluation and identification of emerging customer needs. To develop the joint R&D work program, shareholders forward R&D proposals; a shareholder-appointed program advisory committee screens these for approval by the shareholders' board; the shareholders then participate in weighted voting. Eurescom also contracts with EU on a project-by-project basis.

The Study Mission hosts:

- Dr. Claudio Carrelli, Director
- Milton Gupta, Public Relations Officer
- Harald Johansen, Senior Manager for Strategic Studies
- Peter Stollenmayer, Project Supervisor

BASF AG, Ludwigshafen, Germany, *www.basf.com*

With sales in 2000 of €35.9 billion and a workforce of 100,000 employees, Badische Anilin- and Soda-Fabrik AG (BASF) is one of the world's leading chemical companies. Its product range includes chemicals, plastics, colorants, pigments, dispersives, automotive and industrial coatings, agricultural products, fine chemicals, crude oil, and natural gas. Founded in 1865, the company's first products were dyes for the textile industry. In the 1960s, BASF began systematically building production sites abroad. Plants were set up in Brazil, France, India, Japan, the US, Australia, Mexico, Argentina, Spain, Belgium, Italy, and the United Kingdom (UK). Since the 1980s, BASF has also been increasingly involved in the growing Southeast Asian and Far Eastern markets. Subsequently, from the early 1990s onward, more capital expenditures have been centered on China. In 1999, BASF intensified its involvement in plant biotechnology. BASF achieved record earnings in 2000 by expanding sales by 22 percent and increasing operating income by 15.3 percent, to €3.4 billion. In 2000 the company spent more than €1.5 billion on R&D, employing more than 8000 R&D personnel worldwide. Both manufacturing and R&D activities are relatively centrally organized through a unique approach, known within BASF as the *Verbund*, a linked or integrated whole.

The Study Mission hosts:

- Dr. Dagmar Klinge, University Relations and Research Planning
- Dr. Heinrich Reitz, University Relations and Research Planning
- Dr. Robert Parker, Central Research Laboratories

France Telecom R&D, Issy-les-Moulineux, France, *www.rd.francetelecom.fr*

France Telecom (FT) R&D is the main R&D arm of FT, employing 8000 people at eight R&D sites in France and one in Silicon Valley (Brisbane). These sites are a vital competitive asset for FT and are responsible for developing almost 80 percent of all of the products and services FT commercializes. FT R&D holds more than 4325 patents worldwide, and it has obtained more than 100 new patents and has had more than 50 new software copyrights registered since January 2000. Internal business groups sponsor 60 percent of its research, 30 percent is centrally funded and more forward looking, and 10 percent is for external companies, including startups. Recently, the number of licensing contracts and technology transfers has increased significantly. On March 1, 2000, the Centre National d'Etudes des Telecommunications (CNET) changed its name to France

Telecom R&D. The company felt that the former acronym no longer accurately reflected the reality of its missions, which have evolved considerably in recent years. .

The Study Mission hosts:

- Pascal Viginier, Director, France Telecom R&D
- Jean Marc Rousseau, France Telecom R&D
- Charles Duke, International Partnerships and Relations Manager, R&D Strategy

Renault Technocentre, Guyancourt, France, *www.renault.com*

The Renault Group's business focuses on two main areas: making vehicles and finance. Renault employs more than 166,000 worldwide. After acquiring an equity stake in Nissan, the Renault-Nissan group is now ranked fourth worldwide in the automobile industry, with a 9.2-percent worldwide market share. The Automobile Division designs, produces, and markets passenger cars and light commercial vehicles, as well as agricultural machines through Renault Agriculture. Renault is the leading brand in Western Europe in all the passenger and light commercial vehicle markets. Revenues in 2000 were €31.5 billion. The Finance Division, with FY 2000 revenues of €1.7 billion, encompasses some 60 companies, including Europe's largest car loan group in terms of the number of vehicles. Renault is also the principal shareholder of the new Volvo Global Trucks unit, through a 20-percent equity stake in the AB Volvo group, which it acquired by selling its Renault V.I./Mack commercial vehicles division. Overall, the corporate R&D budget is €2 billion, or more than 5 percent of sales. Approximately 10,000 people work in the Renault R&D division, including 7500 in the organizationally and architecturally cross-functional "Technocentre" the ISM team visited in Guyancourt.

The Study Mission hosts:

- Kim Lansford, Manager, International Research Group
- Jean-Paul Hermann, Executive Assistant, Research Department

Saint Gobain, Paris, La Defense, France, *www.saint-gobain.com*

Saint Gobain is a leading international producer, processor, and distributor of materials, including glass, ceramics, plastics, cast iron, and new materials. Through more than 1000 consolidated companies, Saint Gobain operates in 50 countries worldwide, is one of the world's 100 leading industrial corporations, and employees more than 171,000, three-fourths of whom are outside of France.

Founded in 1665 as a manufacturer of glass plates, its 17th century technological breakthrough was the ability to make very large glass panes, which were used to make mirrors. Now, more than 300 years later, 40 percent of the company's €29 billion in revenue remains in the glass business. For example, the firm provides glass for 50 percent of all cars in Europe, manufactures more than 30 billion bottles and jars annually, and insulates one-fifth of all new homes in the US. In addition, 14.5 percent of revenues is in high-performance materials (ceramics, plastics, and abrasives), and 45.5 percent is in housing (home and office construction materials, building distribution, pipelines, PVC, and cast iron piping). Research funding is about €300 million annually with 3000 people on staff in 16 R&D centers, each associated with a business group. These centers are complemented by approximately 60 smaller development units specialized in pilot projects and joint activities with the main production sites. Although most research centers are located in France, Saint Gobain also has important centers in Germany, Spain, and the US. Additionally, two laboratories are operated in cooperation with the French national laboratories Centre National de la Recherche Scientifique (CNRS) and Commissariat à l'Energie Atomique (CEA). R&D expertise is centered on high-temperature processes, engineered microstructure materials and ceramics, plastic materials and cements, surface treatments and coatings, and composite materials.

The Study Mission hosts:

- Jean-Claude Lehmann, Vice-President, Research and Development
- Helmer Rädisch, Vice President, Human Resources

SAES Getters, Lainate, Italy, ***www.saesgetters.com***

SAES Getters was established in 1940 and is the world leader and pioneer of getter, gas purification, and impurity detection technologies, with 80 percent of the gettering devices and components market. A getter is a device (usually a metal alloy component) used to maintain very high vacuum or to ensure high purity of gas for industrial and scientific applications. Common applications are flat-panel displays, cathode-ray tubes (CRTs), industrial lighting, electron tubes, gas purifiers, and other industrial applications. SAES Getters is also a leader in ultra-pure gas-handling equipment, purifiers, trace impurity analyzers, and quality assurance certification services. The company has 10 manufacturing facilities, 350 employees, and a group of 21 companies linked by co-competencies. Corporate headquarters and the central R&D laboratory are near Milan, Italy. Annual revenues are approximately €160 million. SAES Getters has continuously invested approximately 10 percent of sales in R&D and has produced more than 250 patents. SAES Getters' core competencies and technologies include special metallurgy, vacuum and ultra-high-vacuum technologies, gas surface interactions, ultra-clean gas purification and handling, gas analysis, and impurity monitoring.

The Study Mission hosts:

- Dr. Paulo della Porta, President and Group CEO
- Dr. Bruno Ferrario, Director, Group Research and Development
- Dr. Claudio Boffito, Deputy R&D Manager
- Enio Gualandris, Director, Group Human Resources

ST Microelectronics, Agrate, Italy, *eu.st.com*

ST Microelectronics designs, manufactures, and sells a broad range of semiconductor integrated circuits and discrete devices. ST Microelectronics is the world's leading supplier of MPEG-2 decoder integrated circuits, digital set-top box ICs, and EPROM non-volatile memories. It is also the second leading supplier of analog and mixed-signal ICs, disk drive ICs, and E-EPROM memories. By focusing on dominating these niches, it has become the sixth largest semiconductor company in the world, with FY 2000 revenue of $7.8 billion (US). The group comprises than 40,000 employees, 12 advanced R&D units, 33 design and application centers, 19 manufacturing sites, and 74 sales offices in 27 countries. ST Microelectronics N.V., formerly SGS-Thomson Microelectronics N.V., was formed in 1987 by combining (Italian) SGS Microelettronica and the non-military business of the Thomson Semiconductors division of (French) Thomson-CSF. Today, public shareholders own 56 percent of ST Microelectronics, and the Italian and French governments and private shareholders own 44 percent. Each year ST Microelectronics invests a significant proportion of its sales in R&D and capital expenditures. In 2000, it invested $3.3 billion (US) in capital expenditures (42.4 percent of revenues), and $1.1 billion in R&D (13.1 percent of revenues). ST Microelectronics is also active in numerous collaborative research projects worldwide as well as important in Europe's advanced technology research programs such as MEDEA+, and its predecessors, MEDEA and JESSI.

The Study Mission hosts:

- Giuseppe Mariani, Vice President, General Manager of Agrate Site
- Dr. Giuseppe Zocchi, Vice President, Director, Central R&D Technology Sector
- Dr. Giordano Zanetti, Group Vice President, Strategic Planning
- Alessandro Brenna, Corporate Strategic Planning, Director, Business Development

C. Results of Study Mission Discussions

In this section, we summarize the results of our discussions with the host organizations on each of the six suggested topics. Not all topics were discussed in depth during every visit; instead our hosts selected the topics they wanted to discuss with us, so we could go into those in some depth. Thus, some topics are covered less completely than others. For each topic, we begin with our summary and conclusions, and we follow with reflective excerpts from ISM team members' notes.

Topic 1: EU Business Environment and Government Policies
Every country and region has its own business environment, with relative strengths and weaknesses in technology and business performance.

- What do you consider the technological strengths and weaknesses in Europe that are relevant to your firm's principal businesses? What are the technological strengths and weaknesses of your industry, university system, national government, and EU institutions? How do you exploit these strengths and compensate for these weaknesses in Management of Technology and Innovation (MOTI)?
- Which national and/or EU policies and institutions have the most significant effect on MOTI in your firm? Why? (e.g., EMU? EU regulatory harmonization? R&D subsidy programs? Privatization of nationally owned firms? Intellectual property/patenting? Tax/fiscal policy? Capital market structure? Social welfare policy? Labor unions? Government organization? Industrial policy? Long vs. short time horizon? Others?)
- What business and technology approach are you taking with respect to recently democratized states in Eastern Europe? What impact if any do you foresee as EU membership expands?

Topic 1 Summary & Conclusions
Having been well briefed on EU institutions and cooperative R&D programs by our day of discussions in Brussels and as traveling Americans eagerly anticipating the approaching everyday use of the Euro, we had expected this topic to be of significant interest to our European technology management colleagues. Surprisingly, however, this topic uniformly turned out to be of least interest and generated only limited discussion, except at the collaborative longer-range research institutions IMEC and Eurescom, which get significant funding from the EU. Even the new joint European patenting system was largely unmentioned, which surprised us given the role of IP for most of our host firms.

When the topic was discussed, the EU's most important role was defined as enabling standardization—which is often critical in high-technology industries—and as fostering labor mobility and infrastructure. In particular, our hosts were generally hopeful that the labor mobility regulations and mutual recognition of technical degrees, coupled with the expected Eastward expansion of the EU, might help ease tight high-skilled labor markets so that firms could more readily hire technical staff from wherever available. However, several times we heard that, despite the EU, Europeans remain largely unwilling to move across national borders, or even to relocate regionally. So too, the ISM team noted a continuing strong sense of nationalism wherever we went, although perhaps somewhat diminished compared with ISM European visits in previous years.

The following excerpts from the participants' notes on some of the site visits reflect our sense of the organizations' additional reactions to Topic 1.

Philips Consumer Electronics

Although Philips has been a major proponent and participant in EU collaborative programs, Philips personal had little to say about the topic. The company does participate in some EU-funded projects, but they are a very small fraction of its R&D activities. Philips has been forced, by the size of its home nation, to be a global company for many years, so the EU integration and standardization efforts are not seen as having much impact now on its business success.

ASML

ASML uses government subsidies to help fund its R&D investments: 86 percent of the government funding is from The Netherlands' government and 14 percent from the EU. Technology Development Credits (TOKs) are repaid when the technology is delivered to the market and generates revenue. ASML received €36 million in subsidies (€19 million in non-TOKs; €17 million in TOKs) out of a total R&D budget of €173 million. ASML is also a preferred partner of the partially government-funded IMEC. IMEC uses ASML lithography equipment (obtaining it relatively inexpensively); in return ASML obtains process technology expertise from IMEC. ASML has some engineers onsite at IMEC. In terms of the broader business environment in Europe, ASML's geographic and cultural proximity to IMEC, Phillips, and Zeiss as key innovation partners is an advantage. The disadvantage seems to be ASML's marketing and distribution capabilities in Japan, due in part to its European origins. In contrast, local companies Nikon and Cannon enjoy higher market share in Japan. We note, sympathetically, that our American companies uniformly have similarly difficult experiences in trying to capture Japanese market share.

IMEC

Of all our site visits, IMEC probably is the most reliant on European-level programs. About 15 percent of IMEC's budget comes from the EU, the European Space agency, or other non-Flanders government sources. IMEC participates in a number of EU-funded projects, including Neuro-Electric Synapse—an effort to couple microelectronic chips with neurons—and Bio-SiP—a biological system on a silicon package—and others in microfabrication, in opto-electronic interconnects, and in light-emitting diodes (LEDs).

Siemens

Siemens is truly a global company with about 40 percent of sales from non-European countries. This matches its R&D staffing as well: 40 percent of its 57,000 R&D employees are outside of Europe, and the company even recently opened an R&D facility in China. So, Siemens is not focused specifically on the European environment. Expansion into Eastern Europe is under way, but slowly. Siemens managers believe that cultural and business environments differ widely throughout the world and, rather than seeing it a negative, they try to turn that recognition to competitive advantage. Regional units are responsible for business strategy within their own countries, and Siemens uses local people as much as possible in its regional operations. This enables Siemens to be close to the customers in those specific countries and to understand their unique requirements and regulations.

Only about 2 percent of the overall R&D budget comes from EU funding for Siemens. To qualify for this funding, Siemens said it must work with competitors, and that means making compromises. Therefore, corporate R&D prefers to avoid those relationships because the payoff is perceived as limited.

Siemens does see the European environmental requirements as an advantage, both as a potential market for some of its environmental technologies, and also because of Siemens' general philosophy of doing business in as environmentally sound a manner as possible. Because managers believe they are already doing business in an environmentally sound manner and have significant experience in doing it efficiently, the company believes more stringent EU regulations will force other companies to try to catch up, giving Siemens a competitive edge.

Eurescom

Eurescom views the most important aspects of the European environment as the liberalization of telecommunications markets, beginning with initial EU liberalization regulations in 1987, followed by competition in mobile and cable in 1990, and full telecommunications liberalization in 1998. As a result, more than 200 telecommunications operators are now in Europe, and the price of services continues falling. Therefore, many operators are short of cash, which hinders their ability to invest in improving infrastructure or in R&D. This makes collaboration with Eurescom particularly attractive.

Key telecom issues in Europe these days include interconnecting all the many systems and layers; unbundling the local telecommunications loops; network sharing among the operators to save money; and the technical convergence of television, data, and telecommunications.

Eurescom has worked closely with the European Commission to shape EU collaborative R&D programs, such as the "Information Society" program. There is also a European initiative called e-Europe, which aims to "bring Europe online," for which Eurescom's R&D projects are important.

BASF

BASF, a 300+-year-old company with most of its technical staff from Germany, believes the EU has had very little impact. The company's strengths are its long-term reputation as a leading company in Germany and its involvement in developing the shape of how the university system programs work. BASF believes potential German employees view it as a highly desirable places to work. Thus, recruiting has not generally been an issue, and the company foresees little impact of changes in the EU toward Eastern Europe. It already recruits from and sells products to these states. In addition, BASF's markets are already so global the impact will be minimal. Because of the centralized *Verbund* approach to R&D, managers also saw little advantage to any potential Europeanizing of technology management practices, nor was privatization of nationally owned firms seen as a significant issue.

France Telecom R&D

The government-owned history of FT notwithstanding, the government institutions topic got only very limited airing. The following events have clearly influenced FT R&D, but the ISM team discussions did not go into detail about their effects on FT R&D's business today:

- 1993 European Commission announcement concerning opening all telecommunications services to competition
- 1997 FT stock listed on the Paris and New York stock exchanges
- 1998–2001 Complete opening telecommunications markets to competition; Competitive unbundling of fixed telephony lines

FT already has an R&D laboratory in Poland. The company strategy is to focus on the new telecommunication market segments, including Eastern Europe, to become a global European operator and to provide global services to multinational corporations. We presume that the strategy would have been different before the democratization process, that FT's strategic move away from being a national utility must have been very largely enabled by EU open-market policies, and that current technology strategies must be driven significantly by market liberalization. However, we again note our collective sense that what we Americans see as remarkable progress along those lines is now taken for granted and overshadowed by other issues in the hectic bustle of everyday R&D decision making. The topics just did not come up often.

Renault Technocentre

Renault was one of the only visits where managers expressed their belief that their European environment—particularly vehicle safety and environmental regulatory issues, but also cultural differences and (partly tax-driven) preferences for fuel efficiency and small-sized vehicles—limited the company's ability to compete globally. When asked, for example, whether Renault had plans to re-enter American car markets, the managers were quite open in their skepticism that Renault could leverage its broad European success into success in US automobile markets. The tastes and regulatory differences were just too great, in their view, to enable Renault's European designs to work for American markets.

Renault remains 45 percent government owned, and the CEO is a former government functionary and a friend of the Prime Minister; thus, the government influence remains strong, and perhaps the R&D agenda is more driven by public issues such as the environment and safety than it might be otherwise. Specifically, as a participant in 32 national projects, the firm receives a significant fraction of France's transportation-related R&D funds, through programs such as the Interministerial Land Transport Research and Innovation Program (PREDIT), a €1.1-billion R&D initiative more than 4 years old to develop cleaner, more efficient ground transportation. Renault also participates in 43 EU collaborative projects, such as EURCAR, in areas such as safety, air quality, and fuel and battery efficiency-related topics, but the budgets and impact on the firm were viewed as quite modest.

Saint Gobain

Only a small portion of Saint Gobain's research funding (a few percent) comes from EU and French government funding. This point was not extensively discussed.

SAES Getters

The main government institutions useful to SAES Getters are those for establishing and enforcing intellectual property protection. SAES Getters uses its IP as a barrier to entry for other competitors in the getter market. SAES Getters does not participate in the EU to solve global issues or use funding. However it does use university relationships to a large extent, working with the research laboratories and relying on the professors as a resource to recommend strong students for future SAES Getters employment.

SAES Getters believes Europe has the upper hand in its market because SAES Getters has a “super dominant” position within its current market focus, owning about 87 percent of the market for controlling impurities and purifying gases. It has become expert in field pricing in this market, keeping prices low enough to exclude potential competitors from the company’s “monopoly/oligopoly.” This is also a fairly slow-growing market, which should also detract potential competitors. Current competitors include a Chinese company that has mimicked some of the old SAES Getters technology design with a manual manufacturing scheme and Toshiba, which still uses SAES Getters for its critical purification needs. We also note under this EU environment and institutions topic that SAES Getters’ slow growth and low pricing strategy is likely to minimize European Commission anti-trust regulatory concerns, despite the dominant market position.

Financial market liberalization has also been somewhat important. SAES Getters was the first Italian company to participate on the American NASDAQ stock exchange. This not only increases liquidity, but also provides the company an attractive ability to offer stock options for its employees within the US. This option is considered a retention tool and a financial offering for its US employees.

ST Microelectronics

The Italian and French governments each hold a 22-percent stake in ST Microelectronics. The Italian government, in particular, has had a keen interest in semiconductor technology from the inception of the industry in the late 1950s. ST Microelectronics participates in the Eureka program for a small portion of its R&D funding and participates in IMEC.

Of all the firms we visited, ST Microelectronics appears to have benefited the most from EU or Eureka R&D programs, particularly from the MEDIA/JESSI collaborative semiconductor program. As Europe’s leading semiconductor firm, it has been vital in guiding the strategic direction of MEDIA/JESSI, and it has directly benefited from the billions of Euros in semiconductor R&D investments those programs have made more than the years.

Topic 2: Strategic Direction of R&D/MOTI

Effectively managing the R&D function and the technological innovation process in the firm requires a close integration with competitive/business strategy.

- How does your firm ensure that the R&D function is being managed in a way that it effectively supports your competitive/business strategy? What are the linkages that you have created between R&D and competitive/business strategy and what processes do you use to identify and pursue strategic opportunities?
- Do you use any *portfolio management* concepts or techniques in managing the range of projects and programs in the R&D function? If so, what has your experience been?

- In developing an *R&D Portfolio* of programs and projects, how much emphasis do you place on *technology drivers* as opposed to *market drivers*? [I.e., to the potential inherent in the technology (*technology push*) as opposed to the potential opportunity in the market (*market pull*)?]

Topic 2 Summary & Conclusions

Just as in the US, the European companies visited have varying ways of linking R&D investment to their overall business strategy. Some use formal means, tightly linking R&D with the central business strategy. Others seem to give R&D more flexibility, not constraining it to serving only the current strategy. Each company had some unique ideas. Siemens and SAES Getters are two companies that exemplify what we thought were excellence in this area (discussed in this summary), although we were also quite impressed with processes at ASML and ST Microelectronics, discussed in more detail in the comments section.

Siemens exemplified the best practices of a large technology firm. Managers there link R&D efforts to business strategy in both the short and long term. As in many of our US firms, the Siemens management sets the proportion of R&D investment for product development in existing businesses and that spent on basic research and future business. This proportion is relatively fixed; it is a starting point for budgeting, not a result of the planning process.

Siemens has recently worked to improve the link of R&D investment to business strategy in the short term. Recognizing that its product divisions (also like several of our companies) had drifted away from customers, it established a program to drag these divisions back. Managers took centralized sales and marketing and tied some of it back to the division. Also, they adjusted rewards and other business incentives to ensure that the market would drive short-term R&D. It was interesting that Siemens took this action; as US technology managers, we are familiar with a similarly sized US company that took exactly the opposite action when similarly confronted. Sales and marketing resources were centralized even more than previously. It appears Siemens made the better choice.

Additionally, Siemens has worked to improve the link between long-term R&D and business strategy. It has developed a highly appealing and comprehensive vision of the future evolution of everyday life and technology and has presented it throughout the company. This vision will not only guide the expenditures in central R&D (long-term basic and applied research) but also in the operating divisions. Again, this was similar to the future visions of our US companies, but Siemens appeared more effective in communicating its vision internally than many of our firms.

Similarly, SAES Getters, a small but growing technology company, impressed us with the thoughtfulness and formality of its business processes. Unlike most of the small (and many large) companies we have experience with in the US, it has processes for managing the link between business strategy and R&D investment. Unlike Siemens, It does not set a fixed proportion for future R&D and short-term product development. Rather, projects in both categories are reviewed together three times a year, and management decides on each in the full context of the company portfolio.

SAES Getters is also impressive in the amount of thought managers give to disruptive technologies in both business strategy and R&D investment. Executives recognize that, because their business it specialized, it is highly dependent on the continued viability of technologies like CRT displays. Aware that substitutes for CRTs are being developed, SAES Getters works to find other markets for basic competence and to expand current competence in other areas.

In conclusion, we saw two key lessons for our companies. First, diversified companies need a strong future vision to guide technology development along with business strategy. This vision must not only be developed, it must also be communicated and used in the strategic decision process. Second, both large and small companies should be more mindful of disruptive technology in business and technology strategies—investing, at the least, in targeting the risks. At best, future R&D investments should be strongly influenced by this information. It is a must for any small company and a key to continued success for large companies.

The following excerpts from the participants' notes on each site visit reflect our sense of additional issues in some of the organizations' reaction to Topic 2.

Philips Consumer Electronics

Philips has three principal levels of R&D activities: (1) corporate research where basic research and entirely new concepts and principles are developed; (2) the Advanced Systems and Applications Laboratories (ASA), which does first-of-a-kind product development and prototyping; and (3) business unit product development. Philips does significant basic research in house. One-third of the corporate research is independent and is not funded by divisions. To ensure market relevance, two-thirds is contracted with divisions. By comparison, the business units pay for 95 percent of ASA's activities; 5 percent is for developing new competences.

One of Philip's main competitive strategies is strong forward integration, relying on economies of scope, scale, and learning to exclude competitors. For example, the Philips semiconductor has approximately 70 percent of the analog TV chip market, which is advantageous to the Philips TV business.

As part of the strategic process of tying R&D to business strategy, the business units prepare 1, 3, and 4-year roadmaps, a particularly helpful process for ASA so its managers can anticipate product development and prototyping needs. Another strategy in Philips product development is strict control of components standardization to minimize the number of suppliers. For example, Philips has a favored list of printed circuit board suppliers, coupled with standard design rules for new electronic products with circuit boards.

ASML

ASML appears to spend significant time on competitive strategy development. Clear linkages exist between the strategy and R&D investments and portfolio management to allow it to sustain its newly attained number-one market share position. A strong supplier network is at the center of ASML's business and technology strategy, focusing on system integration of world-class technologies in imaging (Zeiss), stage mechanics (Philips), and metrology (Agilent). This strategy drives relatively low owned R&D investment and competency building in partnership management.

ASML's customer value proposition is threefold: new technology on time; fast ramp to customer volume; and superior customer support. At its simplest, its strategy might be described as "speed and size translates into profits." This clear articulation drives much of ASML's investment, business, and technology strategy. ASML also recognizes the value of concurrent engineering, with development and production teams working closely from the beginning of projects. Moreover, ASML focuses on design for manufacturability, with a modular design allowing ASML and suppliers to perform component testing. This approach reduces and simplifies system integration and system testing; it also accelerates cycle time at ASML and set-up time at customer sites.

ASML's world-class logistics and manufacturing process supports the business strategy. A good balance of technology and market drivers is considered in the R&D portfolio process (evaluating how to get the most out of current lithography technologies and methodologies, and what next technologies are best for investment). Further, other business opportunities are explored for new applications of existing technology and for vertical and/or horizontal integration.

Frontier Design (now Adelante Technologies)

The market drives R&D at Frontier/Adelante. By offering design services and selling its software design tools, the firm learns directly what customers need and what application areas are hot. Managers review strategy twice yearly and perform market research to confirm their choices of application areas. They base their pricing on customer value rather than cost plus.

IMEC

IMEC has a unique business model of developing intellectual property through forward-looking collaborative research programs and facilitating the sharing of emerging technologies exclusively through worldwide networking and partnering. Through the IMEC Scientific Advisory Board, managers work closely with industry and universities to identify longer-range industry needs, then undertake R&D along the farther reaches of that roadmap. Part of IMEC's strategy has been to develop an internal portfolio of background in-house expertise.

IMEC is funded in part by the Flanders government, so it also tries to reinforce local industry through technology transfer and spin-offs (~20 so far) and to help attract foreign investment and international talent to the region by being a world-class center of semiconductor expertise. Yet, IMEC can undertake longer-range activities in part because the Flanders government gives it 5-year grants. This reduces the demands for near-term commercial success and excludes politics from directing the research. By comparison, we note that the US political process yields considerably shorter-term annual budgets.

IMEC also perceives part of its mission as promoting spin-offs of its expertise, which then fosters regional economic growth and employment. The 20 high-technology companies spun off from IMEC now employ more than 500. To facilitate this strategy, IMEC created a venture capital fund. IMEC's internal staff can propose spin-offs, and an internal business development group works to help develop the business plans and attract venture capital.

The venture capitalists take equity in the spin-offs, but IMEC generally gets a share as well. In addition, the region has created a supporting infrastructure of new science parks, as well as a regional alliance-brokering network, "Leuven, Inc.," with particular emphasis on private venture capitalists.

Personnel turnover is another IMEC strategy for transferring technology. About 1100 people work at IMEC, but 250–300 of those are seconded by companies or visiting students. Therefore, 25 percent of the staff regularly rotates out. Of the remaining 800 or so, about 120–150 leave each year, 75 percent of which go into local industry. IMEC has intentionally limited the number of career research slots in house. By last count, about 1200 former IMEC employees have stayed and now work in local industry.

Cambridge Silicon Radio

CSR is a small one-product-line firm with an overall company strategy that dictates much of its technology selection. Its competitive strategy is to be the fast first mover, low-cost leader and to drive production pricing to targets that enable its customers' industries. This strategy has forced CSR to adopt a "license free" strategy: that is, with its cost targets, CSR cannot afford to pay royalties for product development. So, managers must use an appropriate design technology choice for this approach. For example, personnel select standard, rather than leading-edge, 0.35-micrometer CMOS as the silicon platform. This enables CSR to use almost any of more than 50 silicon vendors in the industry at highly attractive pricing. The firm has been extraordinarily successful, but we saw future disadvantages—primarily related to the size of this start-up firm and its (presently admirable) near-term focus—as CSR revenues nearly exclusively rely on the market success of Bluetooth standards. We are unsure what longer-term strategy the company had should Bluetooth be displaced. The managers described a customer-driven process that involves a small team of about three key marketing people who regularly talk with customers; then, four times per year after board meetings, the managers discuss strategic direction. Although our hosts said they are working on a single-chip integration of the competing 802.11a local area network (LAN) standards, this struck us as a fairly short-term approach. One strategic mechanism the firm did mention was participating in standards organizations; CSR has had some success getting its protocols adopted as part of industry standards. A second mechanism was through the influence of ownership ties, as CSR chips go into products at SONY, one of CSR's investors.

Siemens

We discussed the strategic vision process at Siemens with considerable admiration above, so here we add a few additional observations about the structure of innovation decision-making at this huge firm. Siemens is organized to optimize interaction with the customer, a change from its previous focus on internal partners. It is important for each group to build networks and relationships with its customers: thus, key account managers represent their business groups in R&D planning, and the business groups are responsible for developing their product roadmaps. Their focus is on today's business. About 70 percent of business group R&D is short-term, focused on defending the core business; about 20 percent is new business, and 10 percent is discovery.

The role of Corporate Technology R&D is to work with the different business groups and research, develop, and consult in strategic technologies for company businesses. In the R&D organization, executives have key account managers who act as heads of their virtual group laboratories. These R&D groups develop roadmaps based on technology requirements and customer requirements and put this into process maps. Corporate Technology controls the company's broad, longer-term technology roadmap. The business groups retain the product roadmaps, which tend toward the short term. Technology planning is done once a year with the business groups and corporate technology working together: long-term R&D is monitored by the Innovation and Technology Committee, consisting of heads of each business group, with focus on research development and consulting in strategically important technologies. This group then reports directly to the Corporate Executive Committee.

Eurescom

Eurescom is paradoxically both at the giving and receiving end of strategic planning. As a cooperative R&D organization, its mission is to help its members plan for future technology needs by coordinating forward-looking, pre-competitive research into emerging market needs, standards, and interoperability issues, then developing technology and market roadmaps. Yet, the members directly direct Eurescom's own activities. To develop the joint R&D work program, Eurescom establishes a guiding set of R&D themes, then shareholders forward R&D proposals in response to a call. A shareholder-appointed program advisory committee screens the proposals, the shareholders' board approves them, and the shareholders participate in a weighted vote. Eurescom then funds the research from a common pool paid into by the member firms based on their revenues. The pool for common research amounts to about 1–2 percent of the firms' total R&D. The firms very often contribute their own resources on top of what they receive from the central pool.

Eurescom's collaborative R&D projects focus on five program areas: applications and services (28 percent of budget), middleware (10 percent), multi-service networks (42 percent), security, and customers and markets. From this distribution clearly the most important area for collaboration is in improving the inter-operability of all the multiple networks run by the many competing telecommunication services. Multi-service activities also include new access and transport technologies, interconnections, and the evolution of networks across fiber, copper, air, Internet, etc. One project developed automated test suites for ensuring compliance with interoperability standards. Work in the application and services area includes new common architectures and platforms so that competitors have common architectures and platform wherever they serve customers. For example, one project involved developing a platform and methods for public Bluetooth access in airports, where inter-working between systems is quite problematic. Others involved developing multi-lingual speech recognition and other language technologies for mobile services.

Middleware activities involve testing products. Customer and market research includes methods for analyzing telecommunication costs, customer needs, and investment risks, and for gathering market data. Security work involves improving confidentiality, public trust, and public key infrastructures. For example, one security project involved how to enable secure mobile commerce transactions on the global system for mobile (GSM) cellular phones. About 10 percent of the Eurescom research is longer term, which managers define as beyond 4 years from the marketplace.

France Telecom R&D

The team did not address this question specifically during the visit. Rather, we drew information from FT R&D website on how the company manages new-generation R&D. The general thrust seems to be customer-driven technology development:

> "France Telecom R&D has set up a transversal, decentralized organization in order to ensure a spirit of initiative, and closer coordination between product development and market imperatives. These objectives involve a number of management activities geared toward evolving capabilities and encouraging creativity on the part of our scientists and engineers…. The customer: a key participant in the design of tomorrow's services and products. One of the main stakes is to anticipate customers' needs for both their professional and private environments. User-oriented research requires constant observation of market trends, not only to meet immediate needs but also to surprise the customer with tomorrow's products and services."

Saint Gobain

Each of Saint Gobain's 16 Research Centers is aligned with one of its nine business groups (flat glass, glass containers, glass reinforcement, glass insulation, plastics/ceramics, abrasives, piping, building material, and distribution). The additional 60 smaller development units are closely tied to a business group as well. The groups fund about 75 percent of the R&D investment dollars in these centers and development units. The groups control this money, making investment decisions with a great deal of autonomy (although Corporate R&D is involved and informed). The remaining 25 percent of R&D funding, although supplied by the branches, is allocated to projects based upon Corporate R&D decisions. The President of Saint Gobain approves a plan that stipulates the amount of funding each branch is required to provide (approximately one-third of the amount invested internally, such that the corporate pool ends up being 25 percent of the total). The Vice President (VP) of R&D then makes decisions about how this pool of funds will be invested.

For about 4 months every year, the VP of R&D collects research propositions from throughout the organization. Corporate R&D opinions and group priorities are added. The result is the Group Research Program, which is presented for approval to the corporation's Executive Committee. When approved, projects are launched and funded from the common pool. The priorities of the Group Research Program are to perform exploratory research, drive toward breakthrough projects, discover and leverage synergies between branches, develop technologies required in growth markets, and develop critical competencies.

Renault Technocentre

Renault is moving to reduce development times and costs. The strategy at the R&D level is to concentrate on a few focused projects, rather than on what officials characterized as a "scattershot, cover everything, approach." Three years ago, about 25 percent of the development budget was for prototypes. Now with computers, managers are reducing the number of physical prototypes in a given development cycle and are doing it faster. Their goal is to reduce development time to about three years, although the leading Japanese firms do it in two years. However, the Japanese approach calls for more hardware and physical testing, which Renault is leveraging through software and simulation.

The huge volumes in the auto industry translate into huge cost pressures and big arguments about more than cutting, for example, 10 cents and 50 grams of weight. So, incremental cost-saving innovations have considerable value, but these are often more at the manufacturing engineering level than at the R&D level.

Broader R&D issues include vehicle air quality, which has been measured as worse than walking on urban streets because fumes collect more on the inside of a car than outside. By heating and cooling seats, designers can save considerably on the rest of the heating and cooling system, so research there is ongoing. Noise modeling and reduction technologies are also a focus, because sound has high value in consumer perceptions of quality and performance. Truck applications are particularly attractive, given the noise issues there, but this is a lower volume market. Air conditioning systems in mid-sized vehicles are larger than the engine itself, so R&D there is a focus as well.

SAES Getters

SAES Getters uses a central R&D approach that we view as an admirable decision-making process given its relatively small size. Primarily, it creates, designs, and innovates at its Lainate site in Italy and uses a global manufacturing approach for releasing customer products. SAES Getters has three technology centers for design work, yet its main core component technologies are developed within the Lainate facilities. Most of its gas purification equipment is designed and developed at the California plant.

SAES Getters investigates new technologies and continually pulls its "future product marketing" information from customers to ensure the company understands emerging needs and new technologies as they occur. Company personnel follow market drivers closely and form alliances with businesses that manufacture the products they deem important for the future. In this way, SAES Getters aligns its business to participate in the strengths of current technology offerings while planning for future needs.

SAES Getters understands the importance of remaining open to new ideas and markets to obtain new business started in its core competencies (gas purification via getter technology). Because a large part of its business has been in tubes (e.g., florescent lighting and CRT displays, both of which are being displaced), SAES Getters recognizes that future needs and technologies will be disruptive, changes important for the group to follow through continual discussion with customers. Much of its R&D activity is in finding ways to integrate its niche gettering products into the manufacturing of newer devices, including those of semiconductors, flat-panel monitors, and cellular phone displays.

Internally personnel create more ideas than are fundable and they decide priority through a structure ultimately leading to a committee decision. Ideas mature within the company through a process of integrating customer needs studies along with studies from the scientists, then moving the technology from the laboratory into manufacturing. The structure is primarily the following three levels: (1) development of the technology need and building partnering relationships; (2) central Technology and Innovation Laboratory process innovation and product design; and (3) manufacturing. The scientific work may result in formal papers to the scientific community, depending upon their IP potential. After the technology is investigated technologically and a business case is determined in Level 1, a management committee hears and reviews a presentation. This links R&D back into the company's business strategy, thereby also merging scientific creativity into business strategy after the committee has prioritized it as a project to develop.

As a result, the SAES Getters portfolio runs the gamut for gas purification design. It involves not only providing the components (getters) necessary to make the process happen, but also selling the tools necessary to develop these and equipment necessary to create a pure environment for a specific type of gas. So, too, SAES Getters has focused on creating components for a variety of environments to reduce its own market fluctuation cycles with the sale of semiconductors or cellular phones.

ST Microelectronics

Of all the firms we visited, we were most impressed with the processes by which ST Microelectronics aligns its strategic vision throughout all levels of the firm. Its employees are well versed in the vision, mission, core competences, and guiding principles of the company. Global R&D, including 12 advanced R&D laboratories and 33 design and application centers, was described as very well aligned with the corporation's objectives.

ST Microelectronics offers a variety of products to its market segments. Some products have technology roadmaps and fit within product portfolios. We did not discuss the effectiveness of portfolios with them.

Central R&D manages semiconductor process technology development. Although some technology development is market driven and pulled into products by particular roadmap requirements, the laboratory primarily pushes new technology out into product groups. Customers have product requirements—speed, voltage, footprint, etc.—but the central R&D team generally dictates process development. Product enhancements often come from the sales offices and development centers. At this level, sales, applications engineering, and development engineering have direct customer contact and customers often dictate the technology.

Topic 3: Managing Decentralized Operations

As more firms decentralize R&D and manufacturing operations around the world, managing a coordinated and coherent program of research and new product/process development becomes more difficult and more complex.

- Does your firm have significant R&D operations in other countries? If so, where and why?
- How do you determine what R&D should be done with what resources in each location? What processes do you use to exert control and to coordinate decisions about staffing and funding at each location?
- How do you measure and reward R&D productivity and performance?
- How do you organize, integrate, and allocate project responsibilities among geographically dispersed new product development teams? What technologies, collaboration tools, methods, or mechanisms do you use for communication among project team members?
- How are e-services changing your internal processes, your products, or new product introduction cycles?

- In managing R&D globally, how do you deal with gender, racial, national and cultural differences in which foreign values, practices, and customs are much different from your own?

Topic 3 Summary and Conclusions

With the formation of a global economy, the trend for large corporations to maintain worldwide operations has led to a dispersion of R&D operations. The ISM students were interested in exploring European companies' perspectives and methods regarding managing such decentralized R&D operations. Most European companies we visited maintain a global presence, with the majority managing distributed R&D operations. Many larger companies maintain a visible R&D presence across Europe and in the US with some also managing operations in lesser-developed countries (e.g., FT in Poland and Renault in Brazil). The notable exceptions were generally smaller companies (CSR and SAES Getters) and BASF, which had a strong company value system regarding centralized operations that extended into its R&D activities. When queried for the reasons why they were decentralizing their operations, the companies consistently responded that they had a need to either locate where the talent pool resides, so as to staff facilities, and/or locate at the knowledge base, in some cases to provide localization to product lines and brands (e.g.; Renault in Brazil). Particularly relevant to this topic, Eurescom is a cooperative organization jointly funded by the European telecommunications industry whose core competence is project management of distributed R&D projects.

Although we found most companies maintained some distributed R&D operations, it appeared that they had more centralized control of R&D funding allocations than do our US companies. The methodology of distributing R&D responsibilities varied from company to company and seemed somewhat dependent on the historic origin of the decentralized sites. For example, ASML (Netherlands) acquired SVG (US), which resulted in instantaneous distributed R&D operations. Similarly, FT's acquisition of Orange (US) gave that company an R&D presence in the US. Interestingly, Frontier Design (Belgium) opened an R&D operation in Florida (rather than California) to maintain a presence in the same time zones as its US customers, while minimizing the time zone difference from its home office. We note with some interest that Boeing's recent move eastward from Seattle came with discussion of similar time zone issues. FT allocated its R&D responsibilities by location (8 foci, 8 laboratories, 8 locations). As mentioned under Topic 2, the Siemens corporate R&D managers set its R&D strategic direction based on its planning model ("*Pictures of the Future*") but allowed its Strategic Business Units to manage the allocation and distribution of R&D funding and resources. We also note that both Philips and Renault had moved to become more centralized, both by relocating into new central R&D facilities—a university-like campus for Philips, and at Renault the Technocentre, what the ISM team called, "matrix-organization-by-architecture."

As managers and employees of companies who pay us, we were obviously interested in the companies' performance and productivity measurement and reward systems. In general, there seemed no universally unique or perceptibly superior methodology for R&D productivity measurement. Saint Gobain appeared to have a clearly defined methodology for tracking projects using metrics and project dashboards including degree of customer satisfaction of R&D customers, number of successful projects and project failures, business productivity and quality indicators, number of patents and royalties, response time of branch technical directors, degree of satisfaction of the President, and ratio of R&D to sales by business. SAES Getters described a unique Strategic Employee Program in which key employees are publicly identified early in their career as having great potential. The employees in this program (about 12–14 percent today) enjoy greater exposure to the chief operating officer (CEO) and key information and bonuses (~20 percent) based both on company and individual performance.

We had very little discussion on how e-services affected processes and products. FT is investing heavily in third generation (3G) technologies for growth—creating the infrastructure and appliances for e-services. Renault described a business-to-business e-services solution it has deployed to enhance supply chain management. Philips mentioned limited success in using e-business approaches to differentiating marketing and product development needs across cultures. The limited discussion on this sub-topic was undoubtedly due to our not meeting directly with those responsible for managing information technology (IT) within the firms.

On the sub-topic of managing cultural differences, it was hard for us as a group from the US to comprehend and appreciate the challenge of regional relocation from country to country. The mobility we enjoy has always provided an ability to draw talent to locations without many of the issues that European companies face. As we mention under Topic 1, although the EU has created some sense of international unity among member countries, a deep-rooted national pride still exists and was visible in the European companies we visited. We were fortunate enough at several companies to have some transplanted American hosts who shared their perspectives on their adjustment to new environments and some insight into managing cultural differences.

Several companies exhibited deeply rooted national pride from their origins and would likely never be considered anything other than a company of the founding country (e.g., BASF and FT). Perhaps as a sign of the more integrative outlook the EU has tried to foster, the new start-ups (e.g., Frontier, CSR, and ARM) seemed to us far less likely to exhibit these traits than the older and larger companies. Firms from the smaller countries (e.g., Philips and ASML) also seemed less nationally oriented. The EU is making strides in enabling mobility of credentials, which has enabled cross-country talent acquisition and cross-pollination of market localization requirements, but the EU does not explicitly confront the issue of differences in national cultures.

Intentions to appeal to broader markets while maintaining their roots were observed in organizations such as Renault, which was trying, although against (to us) obviously considerable cultural inertia, to transition from a French company doing business internationally to a global company with a French flair. Finally, ST Microelectronics had, to us, an intriguing paradoxical combination of an entirely Italian–French feel and history as a company, yet has escaped that inertia with an obviously healthy, uniquely empowering, amazingly cohesive organizational culture and a truly culturally diverse outlook.

The following excerpts from the participants' notes on some of the site visits reflect additional reflections on Topic 3.

Philips Consumer Electronics

We note with interest that when we visited, Philips was actively moving away from distributed innovation activities, both organizationally and physically. Philips was constructing a far more centralized R&D campus near Eindhoven, bringing together what have been more dispersed activities. Managers believe the campus will be more efficient operationally and also facilitate better cross-discipline and cross-project communications—particularly for sharing and transferring tacit knowledge—and also be a more attractive, energetic place to work, helping to attract and retain the best technical talent.

This move to centralize notwithstanding, Philips still has laboratories in Taiwan, China, the US, UK, France, and Germany. One technique its managers used to facilitate communication and networking or research in house was to have internal conferences several times a year. In addition, new hires (e.g., PhDs) first go to research laboratories; then, after 6–8 years, they move to other parts of the company, such as the product development Advanced Systems and Applications Laboratories for many. As they move, they bring their knowledge with them, facilitating intra-company transfer. However, Philips indicated that moving people with their product through the development phases did not work.

Philips is a global company in many different national and regional markets with differing needs and interests. Local marketing groups keep abreast of local needs. They tried e-business approaches to managing the information need across these—in particular, to gather and share information from customers—but the existing customers in many markets generally were not the users who dictate technology change. In Japan more try-out products are attempted, then eliminated at various stages if customers are uninterested.

When Philips decides to locate oversees, the appropriate people must manage locally. Philips tries to facilitate cohesion with corporate strategies and culture as well as communication to corporate headquarters by selecting from within. Often they find some current employees who are from those countries and willing to go back. For example, about half of Philips' software work is done in India, but the culture is highly different. In India, software developers may be reluctant to admit problems or errors, but to ensure quality they must be open about that. To succeed, Philips needs highly talented project managers able to identify emerging problems early. So working internationally, a company must learn various styles and have relative expectations and degrees of open communication.

ASML

ASML has sales and support offices worldwide and R&D operations in The Netherlands, US, and a few other locations around the world. Its recent SVG acquisition adds 3000 people in the US. Compare this with pre-acquisition ASML staffing profiles: 4400 people, 1400 in customer support, 1200 in Marketing and Technology, 1000 in Operations and Goods flow, and 800 in other. This relatively large increase in R&D scale will stress and strain organization and roles/responsibilities. However, when we visited it was somewhat too early to tell what the longer-term issues would be, and our discussion focused nearly exclusively on the non-SVG activities.

IMEC

Although IMEC is strongly linked into international networks, it is also paradoxically not managing decentralized operations. All the R&D is done at IMEC's central facilities near

Leuven. Partners often do send resident researchers to IMEC to participate and to serve as technology transfer intermediaries. Technology transfer to the sponsoring firms also occurs through publications, electronic means, joint workshops, and conferences.

Cambridge Silicon Radio

Decentralization does not apply to CSR. The company has no significant R&D operations in other countries and is too small to have far-flung sales and marketing operations. However, its markets are global, and US and Asian business dominates CSR revenues. As our high-technology companies clear found when they grew, CSR will undoubtedly begin to face more serious needs to develop management techniques along these lines in its rapid expansion.

Siemens

Approximately 40 percent of Siemens' R&D is done outside of Germany. Business units decide on what R&D gets done in what locations. (See Topic 2 earlier.) Corporate technology is done mostly in Germany.

Eurescom

Eurescom does not do in-house research, so its managers feels the primary core competence as an organization to be the management of distributed R&D groups. To coordinate activities and distribute technical results, they heavily rely on electronic reporting, invoicing, and communication, including audio conferencing and simultaneous desktop document sharing, as well as periodic plenary workshops and European Summit technical conferences, accessible through streaming Internet video. They have found, however, that face-to-face trust building is critical, so they do have joint meetings and conferences 3–4 times annually.

Eurescom executives believe they have developed an efficient structured system of decision making and monitoring, allowing their limited staff of 14 managers to supervise more than 800 project participants across 19 countries in more than 50 separate R&D projects annually. The process and what Eurescom believes are best practices, are set out in a set of management handbooks for the project participants. Eurescom has even promoted its project management skills to the EU as a contract resource to help manage the collaborative R&D projects the EU funds, as well as those funded by Eurescom members.

Average projects last about 18 months and have 4–14 organizations and 10–60 participants. Project management begins with a series of planning meetings to develop project timelines and deliverables. Participants then follow the set of procedures in the management handbooks, available online, although the Eurescom managers expressed the need for flexibility. Although Eurescom provides the project administrative supervision, the project technical leadership comes from the participants.

All the participants are working on the cooperatives projects only part time, which ensures that they can get good experts and, importantly, enables technology transfer into their home organizations. This, coupled with the fact that participating firms receive funding for the projects from the central pool of Eurescom R&D funds, makes accounting for the value of contributed resources the hardest issue.

They believe project evaluation is also a difficult issue, as no specific set of metrics works for all projects. Costs and on-time deliverables of reports and technical achievements are obvious ones; the Eurescom supervisors can hold participants responsible for these. However, the shareholder laboratories are doing the work, and the laboratories do not always have co-incident objectives with either the collaborating companies or often even their own companies. Moreover, the available metrics are often internal to the laboratories, and the business unit personnel generally prefer to keep some information private.

Another problem is closing projects down. After the technical work is done, the companies want to start using the work internally as soon as possible; thus, they are reluctant to produce written reports and final accounting statements. Unfortunately, the reports are important not just for the administrators, but also for the diffusion of the technical results to other shareholders, so the individual incentives do not fully align with the collaborative ones.

BASF

Although BASF is large, we were surprised at the limited relevance of this topic in its management approach. According to company brochures, BASF does do some distributed development work:

> "The central, corporate research laboratories at Ludwigshafen are the competency centers for active ingredients, materials of construction, special effect substances, chemicals, and process development. Decentralized development units in operating divisions and group companies are near to customer needs. Through collaborations with universities and research institutes, joint ventures with highly specialized high-technology companies and own Centers of Excellence, the company gets access to new knowledge and new technologies. These elements can be rapidly and efficiently joined up within the *Verbund* to create innovations that the market wants."

However, with its integrated *Verbund* approach, BASF was the most centralized large company we visited in Europe, and it is also more centralized than any of the large US companies we work for, despite having operations is the US and Far East. Decision-making processes and resource authority clearly reside more at the center than for any other international-scale company we are closely familiar with.

As a minor additional note on the sub-topic of e-services, changes in e-services appear not to have a significant impact because the company receives raw material and sells to an end-user provider. Its products are largely intermediate materials, sold on a large scale (tons of material).

France Telecom R&D

FT's collection of R&D activities outside of France struck us as rather *ad hoc*, rather than driven by a holistic organizing strategy. We were told that FT operates a laboratory in England because of the purchase of the Orange, California facility, and also because technology coming from the US always seems to go to England first. FT is in Poland for historical reasons; that is, FT inherited a laboratory there by acquisition, so managers have found ways use it. FT did not have a presence in Asia before the Japan operations. The Japanese facility is important because the key telecommunications 3G work and first significant consumer use is in Japan, not in the US. Since FT's market is consumer oriented, managers need to identify how customers use FT's products. In Israel, FT provides consulting services by using the expertise of ex-soldiers. FT is in California to take advantage of ties to Sanford University, the University of California at Berkley, and the industrial synergies of Silicon Valley. A group is in New York also for historical reasons and for proximity to the Boston area: that is, FT maintains a good relationship with the Massachusetts Institute of Technology. Perhaps our impression of a scattershot approach to distributing R&D activities may be more related to having met largely with marketing people and more middle-level technical personnel than with the more strategic-level upper R&D managers we met elsewhere.

It also may be because the firm clearly is still emerging from decades as the nationalized telecommunications company. The French operations were far more holistically structured than the rest. Each site does research in one particular area. Each one of the 8 laboratories in France does research on only one specific area: Mobile Services and Radio, Multimedia Services, Network Architecture, Transport and Access networks, Human Interaction, Software, Valorization and Technology Acquisition, and Advanced Voice and Data Services. All research is done to support the parent company.

Although it is the central R&D arm, FT R&D strongly favors applied research more than basic research. Internal business groups sponsor 60 percent of its research, 30 percent is centrally funded and more forward looking, and 10 percent is for external companies, including startups. Because the business groups dominate, the laboratory technical staff and the marketing group have close ties. Teams comprise marketing personnel, engineers, and various other functionaries. They feel this improves communication and helps them anticipate new and critical skills needed to stay competitive.

Renault Technocentre

Renault has brought the vast majority of it R&D staff, 7500 out of a total of about 10,000, together in its spectacular Technocentre. We found this organizationally and architecturally fascinating. By combining horizontal functional groups and vertical product groups, Renault uses a classic matrix organization, but this is reflected physically through the architectural arrangement of the configurable walls and horizontal and vertical floor plans, which are designed specifically to stimulate the communication and information sharing within and among the groups and functions, yet retain flexibility for changing to meet future needs.

As mentioned earlier, except through its acquisition (and subsequent sale) of Mack Trucks, Renault long ago retreated from its US activities; instead, it found the Japanese markets challenging to enter. Therefore, its distributed activities are limited. The recent equity share in Nissan may increase the need for managing across cultural differences and geographic distance, but the alliance is too new for our discussions to generate much. In part because Renault has long history as a nearly exclusively French firm, it is quite proud that 12 nationalities are represented in a single 380-person R&D group. This, executives suggested, was a far cry from an earlier Renault and represented Renault's explicit strategy of transitioning from a French company doing business internationally to a global company with a French flair. We note, however, that in R&D at least, the Technocentre was a clear move toward a more centralized approach. On the flip side were marketing and localization efforts in Brazil, Slovenia, and elsewhere, as well as Renault's continuing series of international alliances and equity investments.

Saint Gobain

Saint Gobain is a global company. To manage its decentralized operations, managers have designed a matrix organizational structure at the company level. The branches can be thought of as the columns of the matrix. Each branch, led by the Branch Director, is responsible for the strategy, direction, and performance of that part of the company. Geographic delegations make up the matrix rows. Within each geographic group, a local delegation is responsible for conducting business across all branches.

Saint Gobain R&D is also highly dispersed. Of the 16 research centers, 7 are in France (900 people), 7 are in the US (400 people), 1 is in Germany (70 people), and 1 is in Spain (80 people). The 60 development centers are in all the areas where Saint Gobain operates. As mentioned earlier, 75 percent of its R&D is controlled largely by the branches and is focused on shorter-term objectives specific to that branch. The remaining 25 percent of R&D is controlled by the VP of R&D and is aimed at Saint Gobain's longer-term objectives, independent of branch.

Saint Gobain assesses its R&D effectiveness yearly at three levels. First, Saint Gobain looks at the R&D program as a whole to ensure that its R&D program is aligned with the corporate strategy. This assessment aims at answering the question, "Are we doing the right research?" This assessment reviews the holistic R&D program, including both the corporate and branch programs. Next, Saint Gobain assesses how well it is executing the program. This review is aimed at answering the question, "Are we doing the research correctly?" This assessment has led to a recent migration toward more formal project management that requires all projects to have a certain amount of formal, consistent structure and expectations. Third, Saint Gobain assesses its general organization, equipment, and competence. In this assessment the company evaluates whether it has the right people, the right tools, and the right processes.

Saint Gobain considers a multitude of metrics including, types of projects (6–7 project types have been defined), R&D effort in growth markets, benchmarking (organization structure, equipment, expertise), sales, market share, project dashboards, customer satisfaction, project success and failure rates, project durations, patents/royalties, productivity, quality, personnel mobility, leadership response time, CEO satisfaction, and R&D investment as a percent of sales.

SAES Getters

SAES Getters has manufacturing facilities in Asia, Europe, and the US. These locations were selected to be close to partners and customers for communication and distribution, rather than for cost purposes. Managers have decided to design the components and create the component material within Italy to assure quality and conformance to the designed specifications. The Technology and Innovation Group also works within this central area to create pilot designs and manufacturing processes. The process and the pilot plant design are then transferred to the manufacturing plants around the world.

Staffing begins with a technical background; therefore, most of those in management and marketing can draw from their technical backgrounds to both push and pull insights into and from the marketplace. They also value staff diversity for learning the market and partnering opportunities. Indeed, the majority of SAES Getters employees are not Italian. To enhance that increasingly diverse staff, SAES Getters has a strategic employee program, mentioned earlier, that provides additional motivation—particularly for engineers. They are given incentives based on 50-percent individual performance and 50-percent business-related bonuses.

Finally, we were surprised given its global markets that SAES Getters does not have much of a web presence. However, it is hard to quibble with a strategy that maintains 80 percent of market share.

ST Microelectronics

ST Microelectronics is also organized using a matrix method; but with parts of the company throughout the world, the executives feel that managing the corporate (not national) culture is the key to success. ST Microelectronics has a global R&D presence; its facilities are in the US, Europe, and the Far East. Central R&D is headquartered in France and Italy where the original partners started. Development centers are in key market areas—Japan, Silicon Valley, Singapore, etc.—for close and rapid access to changing market needs. The business lines fund development centers. Each group is responsible for selecting its product development projects and roadmap. Process/technology development is generally funded through central R&D.

Reflective of its obvious skills at developing a cohesive corporate vision and culture, the ST Microelectronics management team—virtuoso-like—made project integration, communication, and collaboration sound easy. Yet from painful experience we know that is not the case. Its basic management/empowerment model was evident here. Employees have leeway to work on the right projects for business. The ST Microelectronics managers used an "individual drops of water in a unified river" analogy to illustrate how employees could work on things they felt were important as long as they were consistent with the company's vision, goals, core technologies, etc. Employees were clearly empowered, yet paradoxically, that empowerment undoubtedly grew from the vision and direction at the top.

On a more minor note, although the subject did not explicitly arise, we got the impression that ST Microelectronics' internal processes and communication were highly effective. The managers seem to be aware of the many benefits that e-services can provide both with and without sophisticated software.

Topic 4: External Technology Acquisitions Through Networks, Alliances and Acquisitions

As technology is increasingly being acquired from external sources, as well as being developed internally, firms are becoming more active in technology-motivated networks and alliances and in mergers with and acquisitions of other firms.

- Is your firm active in networks or alliances to develop technology, or has it acquired or invested in other firms to obtain its technology?
- If so, how do you select the firms you partner with, acquire, or invest in? Why do you seek the technologies externally rather than developing them internally?

- What methods do you use to ensure your firm can efficiently access, internalize, and use these external technologies?
- How does your firm manage external relationships with regard to establishing goals and responsibilities, resolving conflicts, and ensuring effective communication?
- How do you cooperate with competitors in such alliances/networks?

Topic 4 Summary and Conclusions

All of the hosting organizations indicated that—given the pace of technical change, the technological complexity of most of their products, and the scope of their global operations—technology alliances and networks were central to their competitive and technical success. No firm, not even Siemens, BASF, or Philips, is capable these days of leading in every area. As in the US, these organizations cooperated with many other institutions, including suppliers, customers, potential competitors, universities, and public research organizations. Nearly all the organizations we visited used all such alliances.

Networks have clearly been a significant factor contributing to ASML's market success. Indeed, the ISM student team notes that, even before our visit, one of our US professors used ASML's alliances as a prime example of the network forms of innovative activity that permeate current MOT practices. The company innovates in technology by sharing the costs and risks with its partners in the network, including customers, suppliers, and critical complementary technology providers; by utilizing government subsidies; and by being "big enough to afford" R&D investments. Its network of ongoing cooperation also enables managers to more quickly understand and evaluate emerging technologies through closer access to the expertise.

In general, firms were most concerned about dealing with competitors. But, as with our US companies, particularly in standardization efforts and in longer-term research efforts, the guiding principle was clearly cooperation to enlarge the market, then to compete for a bigger piece of it. Our visits to the cooperative research organizations IMEC and Eurescom were prime illustrations. Both involve highly significant cooperation and joint funding of longer-range research projects among competitors: among European telecommunication within Eurescom and the worldwide semiconductor industry for IMEC. Indeed, Eurescom might be an example of a purely networked organization, as all it does is manage distributed R&D projects among cooperating firms. We note that these are more formal, contractual forms of networks, but we also sensed European managers valued informal networks as well, through acquaintances at technical meetings, serving jointly on technical panels, participating on advisory boards, and so on.

Universities in both Europe and the US are definitely valuable sources of expertise and cooperation; in fact, more than half the firms we visited were eager to advertise their relationships with elite US technological institutions like MIT and Stanford. More so than strict business alliances, these university relationships do seem to be culturally biased; thus, Japanese (or other Asian) universities were not mentioned anywhere.Acquisitions are an important mechanism for access both to technical expertise and to markets, although several firms mentioned significant difficulties in integrating in diverse cultures. Interestingly, the reverse process was also strategically important, as several organizations talked about their explicit processes of spinning off new technologies that were not central to core missions.

ST Microelectronics has a particularly impressive acquisition process, which was especially interesting because of its success in developing a coherent corporate culture despite a continuing series of acquisitions. ST Microelectronics personnel discussed the importance of integrating fast, of expediting the change, and of dedicating the necessary resources to the transition. They believe in the importance of strong decisions made quickly, as doubt and indecisiveness, they said, lead to fear and distrust. The company's process includes setting clear short-term goals, regularly celebrating successes, communicating honestly and openly, and—most importantly—managing the culture. Corporate personnel also place value on the personal issues involved in mergers for their employees, and in keeping a sense of humor.The following excerpts from the participants' notes on some site visits reflect additional reactions to Topic 4.

ASML

ASML's network activities were discussed in the earlier summary. Additional comments follow: ASML also participates in consortiums in Europe and internationally [e.g., the 157-nm Lithography Consortium and the Extreme Ultraviolet (EUV) Consortium] with IMEC and other organizations, as well as its competitors. ASML also recently acquired SVG, which also produced lithography equipment. SVG had acquired Mask Tools in 1999.

Frontier Design (now Adelante Technologies)

This company's experience has shown that geographically distributed teams do not work well, so Frontier does not do it. It does have remote sites, but those are design centers for local customers. Frontier chose to locate in Florida rather than California to facilitate communication across time zones.

IMEC

IMEC would likely not exist except for external technology acquisition: IMEC has 518 partners worldwide who are doing just that through IMEC. It has a unique business model of developing intellectual property through forward-looking collaborative research programs and facilitating the sharing of emerging technologies exclusively through worldwide networking and partnering. For example, in its 193-nm Consortium, IMEC works on CMOS photolithography process integration with AMD, ASML, Cypress, Intel, Philips, Zeiss, and other firms. By working collaboratively, IMEC is optimizing and proving the process parameters and readying the whole integrated process for transfer to industry. IMEC also maintains intense collaboration with universities, and supports small- and medium-sized firms in its semiconductor design activities.

IMEC uses a number of mechanisms to manage collaborative activities, including its multilateral Industrial Affiliates Program, where partners join early in the R&D life cycle and get early access to emerging ideas. IMEC also does bilateral contracts with industry partners.

Cambridge Silicon Radio

CSR partners extensively with OEM customers to assist in integrating technology into its products. Its focus on achieving its cost targets has pushed CSR into being the sole-source developer of its technologies. Thus, CSR has no exposure to licensing agreements and can fully control cost structures.

Siemens

Siemens has set up a technology accelerator group. Thus, Siemens can fund innovative technologies for emerging markets if they add value; the company also provides office space and contacts with venture capitalists. Siemens decides at some point whether the technology should be retained in house or whether to spin off its development. Siemens will partner with other companies where it makes business sense. Siemens has purchased American companies in the past but has found that integrating them into the Siemens culture was very difficult.

Eurescom

Eurescom believes the collaborative R&D programs it manages are valuable to the participating shareholder companies because they share costs and risks and can accelerate projects. Eurescom collaborates on standards and on improving the interoperability of its networks; on improving the reliability, security, and performance of backbone infrastructures all its companies must use; and on better understanding of future markets and customer needs. Some firms like to use the collaboration as a training ground for R&D managers, moving young people through. The participants can also collectively influence standards. Shareholders select those projects they want to participate in, so presumably they perceive mutual benefit. The objective, Eurescom told us, was to "cooperate to expand the cake, then compete to divide the cake." As mentioned in Topic 3, Eurescom believe it has developed unique competencies in managing collaborative networks of researchers spread all through Europe.

Intellectual property agreements signed before projects begin define foreground and background information, what each participant owns beforehand, and what will be shared. And there are two levels of sharing: About one-third of technical documents are fully shared with anyone, even if they do not participate in Eurescom. These include agreed standards and interoperability requirements. The remaining two-thirds are for Eurescom shareholders only. These are sometimes available to those shareholders not participating directly in the project, but only after a lag of 2 or 3 years. Eurescom claims that intellectual property issues have not yet been a real problem. The joint gains are seen as much more important than the risk of losing some IP.

However, Eurescom has found that the acceptable balance between cake growing and cake sharing is different depending on who collaborates. As Eurescom has evolved to begin including suppliers like Siemens, the IP issues are getting more problematic. These manufacturers are far more sensitive to IP than the telecommunication service providers, who compete on a different basis than do the manufacturers.

Eurescom now has a new class of "special projects" outside of the central funding pool, in which shareholders can elect to participate and pay for on their own. In these cases only the participants, not non-participant shareholders, share the IP. This structure is actually quite similar to the two types of Bellcore projects at that US joint R&D collaborative—general interest and special interest. Eurescom thought most of the money at Bellcore went into the special-interest projects.

BASF

BASF believes,

> "the central, corporate research laboratories at Ludwigshafen are the competency centers for active ingredients, materials of construction, special effect substances, chemicals, and process development. Decentralized development units in operating divisions and group companies are near to customer needs. Through collaborations with universities and research institutes, joint ventures with highly specialized high-technology companies and own Centers of Excellence, the company gets access to new knowledge and new technologies. These elements can be rapidly and efficiently joined up within the *Verbund* to create innovations that the market wants."

In addition, BASF forms joint ventures, such as one with Shell that the two companies founded in late 1999 to manufacture polyethylene and polypropylene. Comprising the companies Montell, Elenac, and Targor, the objective of the joint venture is to bundle the innovative capacity of BASF and Shell in these areas and achieve cost advantages through synergism.

France Telecom R&D

FT R&D cooperates with universities, public research organizations (INRIA, CNRS), and private research. FT R&D has built up networks of relations for R&D, which helps accelerate technology transfers. FT R&D appears to have its closest collaborative ties to companies that also have deep French roots, such as ST Microelectronics, Thomson, and Alcatel, although it does participate in Eurescom and the EU collaborative R&D programs. FT R&D cooperates through equipment and software evaluations and through co-development activities. An example is the creation of jointly owned Groupement d'Intérêt Économique (GIE) through licensing and cross-licensing patents and software. FT R&D has had 600 R&D contracts with partner organizations in the past decade, including 300 with small- and medium-sized firms. Company principals believe that partnership with FT R&D allows partners to add more value to its products and services, to reduce overall R&D costs and share risks, and to evaluate emerging technologies through closer access to the expertise. They also select outside partners and marketing specialists who contribute knowledge of specific niches or technical fields. Managers attempt to close holes in the R&D portfolio by either partnership or acquisitions.

Renault Technocentre

The supply system is probably the biggest network issue for Renault, as it buys about 80 percent of the value of a car. So managers maintain very strong relations with suppliers. The purchasing department tries to minimize the number of suppliers to about two for each component or system. However, Renault's existing suppliers, we were told, are not that ready for significant innovation; also, both the 10- to 12-year lifetimes of cars and the service aftermarket need limit the pace of innovation throughout the industry.

If Renault develops an innovation of its own, it often wants to move it into the supply base for high-volume manufacturing. This generally means licensing it for suppliers to sell to others as well (perhaps with a lag time of 18 months or so), to increase the manufacturing volumes and lower costs. Because of this need to license, patent races are not always worth the cost.

Renault recently acquired a 35-percent share in Nissan, which has allowed it to share access to distribution networks, which had different strengths, and also enabled cross-brand platform sharing. Renault also has begun swapping executives and engineers.

Renault participates in collaborative R&D projects, 43 through the EU and 32 French national programs, particularly with companies like Peugeot. Personnel use those collaborative programs as a tool for helping competitors work together. It also allows Renault to see how things are done elsewhere and learn both technical and managerial techniques.

One reason for collaboration is access to local expertise and exposure in places like Brazil. An example was on clean-air technologies in Rio de Janeiro. The partnership was a way to access local environmental expertise and at the same time improve Renault's local corporate image.

Saint Gobain

Saint Gobain has acquired several companies more than the last 10 years. Although Topic 4 was not discussed in depth, our host mentioned that Saint Gobain's human resource managers are working on harmonizing policies and facilitating intra-company mobility to and from recently acquired businesses.

SAES Getters

SAES Getters has alliances with large partners to create products and a need for its components. Without these partnerships, its component business (getters) would be very small. Therefore, these are key elements to its future strategy and thus success. SAES Getters is also active in university networks, as well as in scientific groups and journals. In addition to its internal R&D, SAES Getters works with more than 100 universities. Even although they like to share technology, the managers suggest there is obviously a balance between protecting IP and shared learning. They do not publish everything.

SAES Getters has acquired companies in the past, but this is not a very common practice. These businesses were in similar fields and SAES Getters bought them to build upon existing business. One acquired gas purification equipment company was in California, which also allowed managers to hire qualified people and assume a manufacturing site.

ST Microelectronics

ST Microelectronics has what we saw as a best-of-class model/business process for partnerships, alliances, and acquisitions with the emphasis placed on acquisitions. When faced with a technology need or a strategic opportunity, ST Microelectronics performs a detailed analysis on would-be partners, minority investments, mergers, or acquisitions. Personnel consider whether they can develop a product or process in time for markets and the costs/savings for the different options—outsource, partner, acquire, or develop internally. Very importantly, in our view, ST Microelectronics also makes sure that it has a culture mesh with any would-be mergers and, if so, manages the culture early in the relationship.

ST Microelectronics has a list of recommendations to make acquisitions/mergers go as smooth as possible:

- Integrate fast—don't drag out the change
- Dedicate necessary resources to the transition
- Make strong decisions quickly—doubt and indecisiveness lead to fear and distrust
- Set clear short-term goals and celebrate successes
- Communicate honestly and openly
- Manage the culture
- Remember what the merger means to employees
- Keep a sense of humor.

ST Microelectronics does cooperate with competitors in technology development, for example, in IMEC and SEMATECH International. Executives seem to share the sentiment that we saw at Eurescom: "Cooperate to make the cake bigger. Compete for a bigger piece."

Topic 5: Managing Human Resources in High-technology Firms
The knowledge assets of a firm are increasingly being recognized as a strategic resource that is embedded in the scientific and technical work force. In the US, there is a shortage of scientists and engineers and a tradition of career mobility (leaving one firm and joining another) that is of great concern to high-technology companies.

- Do you have the same demographic problem of a shortage of scientists and engineers and in retaining your company's scientists and engineers?
- How does your firm identify, recruit, and retain scientifically and technically skilled people? How do you motivate, reward, and promote them? Do these practices apply to all professional employees, or are they special to scientists and engineers?
- In what way is your firm or industry working with schools and universities to ensure a continuing supply of skilled scientific and technical talent?
- Have EU labor mobility efforts had any significant impact on your company?

Topic 5 Summary and Conclusions
Because many technology firms in the US had great difficulty in recruiting and retaining technical professionals at the time of our ISM, we asked the hosting firms to discuss their experience in this area. In general, we found the European firms were having less difficulty than our US organizations in filling their engineering and scientist positions. Many of the large, established firms like Philips, Siemens, Saint Gobain, and BASF benefit from their tenure as long-standing, high-quality technical employers in their home regions. This tradition leads large portions of the young technical talent in local geographies to those companies. This said, we note that those companies are increasingly concerned about this topic. Smaller firms like Frontier Design stated that it could not get all of the people that it wanted. CSR commented that its venture capitalists cautioned it on the importance and potential challenge of staffing its new organization with high-quality technical

professionals. Finally, Saint Gobain, a leading employer of engineers and scientists in France for more than 335 years—and accustomed to first pick of French technical talent in materials and related technical fields—stated that managers have noted a decline in the number of unsolicited résumés they receive for consideration. Although clearly not yet a crisis, the European technology companies see a trend toward a reduction in the availability of engineers and scientists.

On a related issue, women were clearly underrepresented in the technical and management fields in all the firms we visited, although we sensed no urgency or significant effort from any of our hosting companies to make this a priority. We note, comparatively, that this issue, without question, remains higher on the attention scale of managers in the US. However as our high-technology businesses have begun to struggle, this issue seems to have subsided somewhat from the attention levels of several years ago.

Gender aside, after a technology firm has acquired top engineering and scientific talent, retention and development become critical. Along with techniques similar to those used in the US, we were intrigued with some other methods less discussed in our firms. As in the US, many of our host companies suggested that professional training is a good way to develop and retain technical professionals. FT R&D finances its employees' PhD theses; SAES Getters sends some of its employees who exhibit management potential to training in the US; both Saint Gobain and ST Microelectronics explained how they have seen the need for a "dual-ladder" development path for technical professionals. As in the US, this structure allows scientists and engineers to continue their professional development and advancement along a technical path, not just into management.

Another technique we found highly interesting was that of making customer contact early in an engineer or scientist's career as a development and retention tool, not just a market needs tool. Both SAES Getters and FT discussed sending their employees to interact with customers in the first few months of their careers. They reported great results for both development and retention.

We also witnessed some creative tools for identifying individual potential early on in a technical professional's career. ST Microelectronics deploys a highly creative metric, a potential-vs.-contribution matrix, which allows managers to find and invest in high-potential individuals. As mentioned earlier, SAES Getters described a formal strategic employee plan that identified and took special care of high-potential employees.

European technology firms, like those in the US, appear to work very closely with universities; and, on curricular issues, they may be even more involved than US companies. As in the US, internships and scholarships are among the methods of university contact. However, for many hosting firms, the relationships seemed to go deeper. Siemens reported it is working with the German universities to shorten the time required to complete an engineering degree. These program changes would provide Siemens with new engineers more quickly. Companies like ST Microelectronics have extended university contacts beyond the local geography, and beyond the most basic methods of interaction. ST Microelectronics has relationships with the top 10 Italian universities and several top US universities. Its interactions go beyond internships and scholarships to include relationships with professors, tutoring, and consortium involvement. We are aware of similar efforts by US firms, such as faculty consulting contracts and financial and infrastructure support for limited numbers of target recruiting schools, for example, but the breadth, extent of interaction, and mutual support seemed richer and more universal, at least across the firms we visited.

On labor mobility issues, our US firms can sometimes find it difficult to get employees to transfer from one city or state to another. We also can find it more difficult to recruit out of state than in our local regions. Our impression was that the European firms experience this difficulty to an even greater extent. Nationalism, cultural differences, and language issues make it even more difficult for European companies to entice their employees to transfer to different facilities across borders and to recruit from other (out-of-country and even within-country) regions. Saint Gobain reported that French engineers and scientists are reluctant to travel to other countries. Interestingly, this difficulty is increasing with changes in legislation that limit the conditions under which French citizens can get credit for government service. Similarly, ST Microelectronics noted difficulty in getting employees from its region around Milan to work in France or even other regions within Italy. Siemens noted that it is difficult to attract foreign engineers and scientists to Germany, but people are more willing to move to the US. Siemens also suggested that nationalistic issues nearly prevent the company from using Western European managers in its Eastern European facilities. As labor mobility is a key focus of the EU, we are interested to see the extent to which this issue exists in the future.

Finally on this topic, we note the strategic use of attractive, energetic campus-like environments at both Philips and Renault in part to facilitate attracting and retaining the best talent from around the world. We also note that IMEC had almost the opposite strategy—intentionally maintaining high turnover to foster industry and economic growth in the region.

The following excerpts from the participants' notes on some of the site visits reflect additional reactions to Topic 5.

Philips Consumer Electronics

In general, managers felt that the demographics in Europe were moving the wrong way, with fewer young people entering technical fields. Philips has succeeded in attracting foreign talent, and now more than 50 percent of its R&D employees are from outside of The Netherlands or Belgium. That fraction was about 20 percent a decade ago. Nonetheless, our Philips hosts believed that Europe remained less attractive to foreigners (e.g., Asians), for relocation than is the US. Those who do come to Europe often want to go back to their home country after a few years.

A significant part of Philips' central strategy for attracting and retaining the best talent was building a high-technology campus near Eindhoven. Part of its mission is to be an enjoyable, fulfilling place to work. Another mechanism for retention is to avoid freezing people to their jobs.

Philips noted that software developers were particularly difficult to find and that a laboratory is in Bangalore, India, because of the skill base. Half of Philips' software is done in India. If Philips does locate facilities oversees, then the company also tries to develop good links to the local universities for recruiting and training. However, managers felt it took a long-term vision, as a long time is required to build significant competencies elsewhere if they don't already exist.

ASML

ASML believed that knowledge is its core competency and most valued asset and that this value is embodied in its employees. Careful management of IP is critical to its success (ASML has 10 people in the IP department, focused on this issue) but so are the people who carry that IP in their heads. ASML has a young, energetic, motivated workforce that is highly educated. They enjoy flexible work hours and management-by-objective environments—even the production workers. ASML's people growth in 2000 was significant, although we saw no hard data on retention and hiring issues.

Frontier Design (now Adelante Technologies)

Frontier specifically located where managers believed the recruiting or retention problems would be minimized. Frontier facilities are in attractive environments (Leuven, Belgium, and Melbourne Florida) with well-educated work forces, yet comparatively limited competition for potential employees. As of our visit in May 2001, Frontier had retained 100 percent of everyone hired. However, more than most of the organizations we visited, Frontier did have some recruiting challenge. Our hosts said they could not hire all the people they want. On the other hand, our impression was that they had not been fully aggressive in trying. Although employee mobility was not a major area of discussion, they did transfer a key software tools design engineer from Belgium to Florida. A "debrief" process retained his tacit knowledge for the Belgian location; that is, he worked to transfer what he knew to three other engineers. He also tried to capture that tacit experience more explicitly by documenting it in the software.

On the topic of corporate culture, the managers mentioned that they liked to hire newly graduated engineers, more than those with experience with design procedures at other companies, so they can be taught the Frontier process without bias or argument.

IMEC

IMEC believes it helps attract foreign investment and international talent to the Flanders region by being a world-class center of semiconductor expertise. It also maintains close collaboration with universities and provides training in related technologies to industry in the area through its Microelectronic Training Center.

In contrast to most other organizations, personnel turnover is an explicit IMEC strategy for transferring technology. About 1100 people work at IMEC, but 250–300 of those are seconded by companies or are visiting students; so 25 percent regularly leave. Of the remaining 800 or so, about 120–150 leave each year, and about 75 percent of those leaving go into local industry. IMEC has intentionally limited the number of career research slots in house. By last count, about 1200 former IMEC employees have stayed and now work in local industry.

Cambridge Silicon Radio

CSR was forewarned early on by the venture capital community that the concerns were significant regarding adequate levels of technical staffing. So, CSR hired a full-time recruiter to address staffing needs when the entire company consisted of only 12 employees. CSR managers believe because of this they were able to grow from 12 to 170 employees in the short time since the company's establishment in 1998. CSR currently maintains four full-time technical staffing recruiters.

Siemens

In Germany, 13,000 new jobs are created each year. Siemens is working with the universities to shorten engineering programs to get people through the university system more quickly. It is also doing marketing at universities, offering internships, and providing scholarships.

Siemens finds it more difficult to recruit foreign employees into Germany than into the US. However, some interest comes from people in Spain. Setting up laboratories in other countries is one way to solve the immigration issue. Siemens has found that employees from Eastern Europe are very good; however, managers need to train Eastern European managers to run those operations since the Eastern Europeans seem less likely to want to work for German managers.

Siemens also emphasizes training employees for the future. Half of its employees go to some type of training each year, some of it international. For example, 12 employees each year go to management training at Duke University. Also, Siemens provides on-line computer-based training for all of its employees.

Eurescom

One issue that regularly comes up in collaborative projects Eurescom supervises is the turnover of participating individuals as they leave, or more often move into other projects for its own companies. This flux means that good informal networks among shareholders and project supervisors must be maintained and that open communication is important. It enables quickly finding replacement people with similar skills, sometimes in different shareholders than the original person. This happens regularly and has worked reasonably well, Eurescom said.

BASF

BASF has observed a slow increase in the number of students taking chemistry, but as a long-established desirable employer in Germany, the human resources (HR) managers think BASF continues to be the German employer of choice of new graduates in chemical- and materials-related technical fields.

France Telecom R&D

Each year, some 150 doctoral candidates as well as high–level engineering school or university graduates are hired or accepted for internships. In addition, FT R&D finances some 50 PhD theses each year at its various locations. One result is that the FT R&D staff is the youngest, on average, throughout the company. Like BASF, FT apparently does not seem to have the problem we have in the US of retaining and hiring enough qualified candidates. The topic of working with universities on recruiting and curricular issues was not discussed.

Renault Technocentre

The HR representative we spoke with at Renault was an American who had worked for a German automobile firm before moving to Renault, so we valued her comparative insights. Renault's challenge, she said, was where to find good people and processes around the world, and Renault saw itself becoming a more global company, but with a French flair. In the R&D area specifically, how could Renault use R&D to promote its image around the world and make good connections in business and politics and, importantly, in recruiting?

Managers considered Renault's worldwide business locations and placed manufacturing operations at the most important places. They also worked with the local universities. By locating nearby, Renault increased the demands on the technical and engineering departments locally, and investments in building them help Renault attract a quality workforce. It also increased the design challenge back in France. Design engineers now have to worry about "tropicalization" of Renault products. They also need to deal with tropical issues in the manufacturing processes. So, local problem solvers are important.

As Renault's presence in these markets matured, the company moved from the basics of how the local markets worked into identifying the best universities for recruiting and support and suppliers with whom to partner locally. Good relations with universities are important because it helps communicate the kinds of skills and students needed. This was not always straightforward, as in Brazil, for example, where industry and universities have little tradition in partnering. Also, a quality supply base in locations like Slovenia takes time to find and develop.

Renault wants to hire non-French employees. In the Technocentre group, 12 nationalities were among the 380 employees, which we were told was a significant shift in corporate culture. However, the German company from which the HR representative had come had 62 nationalities on its equivalent staff. So, Renault was moving but not yet nearly as international.

Saint Gobain

Saint Gobain is well aware of the global shortage of engineers, but it has a relatively unique perspective of the situation. Because of its long-standing reputation in France (it's been there more than 335 years), like BASF in Germany, the company does not yet have a problem attracting top talent in France. It has, however, experienced difficulty elsewhere, specifically in Germany and the US. French managers have not observed a shortage of talent, but they are noticing a reduction in the number of unsolicited résumés they receive. They believe that this could be an early indication of a trend toward a growing issue in France as well. Anther issue, somewhat different than what we deal with in the US, is that French citizens could historically complete their military service requirement by working for Saint Gobain abroad. This regulation has recently changed, and Saint Gobain is concerned that it may lead to less interest in spending one's first few working years in a foreign country.

Most of Saint Gobain's employees are from Western Europe, Eastern Europe, and North and South America. The number of women engineers in the company varies from none, in some small operations, to a few percent in several operations, to nearly 33 percent in a few other operations.

Saint Gobain feels it must maintain the attractiveness of R&D. One way in which Saint Gobain feels that can be done is to define clear career paths through both management and technical expertise. Saint Gobain is currently rolling out a "dual ladder" structure in which engineers and scientists start out as technicians, move through three researcher levels, and then make a decision as to whether to pursue a management or technical path for the remainder of their careers.

SAES Getters

SAES Getters not only trains its own people, but it cycles nearly everyone through laboratory positions before they begin management or marketing training and focus on other jobs. In addition, SAES Getters sends new scientists out to work directly with partners after 6 months of employment. This technique is fondly known as "trial by fire" and is in part intended as a motivational development and retention tool.

ST Microelectronics

ST Microelectronics was particularly strong in HR/management practices. ST Microelectronics uses a classification scheme along "Potential" and "Contribution" axes to group its population. This applies to everyone, including nonprofessionals. Managers appear to do a very good job of identifying high-caliber future leaders early on. They do have some demographic problems hiring and retaining scientists and engineers; in fact, they mentioned that Nokia and Philips alone could probably hire today every European engineering graduate in relevant fields produced in the next five years.

SGS, the Italian portion of ST Microelectronics, has had a long and productive history with Italian universities and appeared exemplary in this regard. SGS works with universities to become integrated with professors, which provides managers with access to top-notch students; For example, SGS provides laboratory equipment and experiments to help make students aware of the company. University partnerships are maintained with about 10 top Italian universities plus leading US technical universities such as MIT, the University of California at Berkeley, Carnegie Mellon, and Columbia. ST Microelectronics' university relationships include working with individual professors; participating in academic conferences; providing lessons, tutoring, and technical support, supplying equipment; supporting theses and scholarships; and participating in alliances, collaborative think-tank institutions, and consortia.

Topic 6: Dealing With Disruptive Technologies

In the US, high-technology firms are concerned with the management of disruptive technologies—technologies that disrupt an established business trajectory or redefine what performance means for a product or product line.

- Does your firm recognize disruptive technologies or radical/discontinuous innovation as being of special interest or importance?
- If so, how do you identify opportunities and encourage its development? How do you deal with its inherent risk and uncertainty? How do you achieve balance in the allocation of effort between them and the more incremental or sustaining technological developments?
- Do you manage projects to develop disruptive technologies differently than other development projects? If so, how?
- How do you respond to the development of disruptive technologies by competitors in your principal businesses?

Topic 6 Summary and Conclusions

Given the pace of change in most of the industries in which our hosting organizations (and our US firms) participate, we were particularly interested in discussing ways to deal with technological innovations that are potentially disruptive to current markets and businesses and approaches. We were impressed with the range of techniques and considerable thought that our host institutions had given this topic. Mechanisms included those for recognizing opportunities and threats, those for managing the risks associated with disruptive changes, and those for evaluating then managing the implementation of new disruptive technologies. We discuss each in turn below. However, the most important technique we found for dealing with disruptive technologies—keeping track of them, gaining access to them, and ensuring effective implementation of them—was in maintaining strong external partnerships and networks of innovation, discussed in Topic 4. Comments here are in addition to that most dominant technique.

Many of the hosting organizations had relatively formal structured processes for recognition of opportunities and threats from emerging technologies. In most cases this was permanent and institutionalized. For example, Siemens, SAES Getters, and ASML organized formal, ongoing business teams with the explicit responsibility for forward-looking analysis and planning.

We considered Siemens' approach the most comprehensive and a useful model. Both Siemens and FT R&D developed forward-looking "future scenarios" for guiding strategy. These were broad and relatively comprehensive visions of what everyday life would be like in the near and intermediate future. The scenarios are aimed at identifying technical needs and market opportunities, then aligning the firms' innovation activities with those opportunities. Philips uses a similar technique called portfolio road mapping; it tries to manage its technical capabilities and set technical objectives to match the long-range trends. Several firms, including FT and Renault also discussed briefly their formal modeling techniques for technology and market forecasting. Philips' approach seemed somewhat more narrowly technically oriented compared with the broader social contexts of the Siemens future scenarios. For example, Siemens did technical trend analyses too, like the road mapping, but then wove them into the broader social fabric of the future scenarios, including trends in politics, the economy, the environment, and social behavior.

Modeling of another sort was also highly important and visible at Renault: actual prototyping of concept vehicles. Renault felt that it could get highly useful feedback from consumers about the appeal of various forward-looking disruptive ideas by putting them in the concept cars. Renault also used reverse engineering of competitors' products to try to understand the likely impact of disruptive technologies. For example, managers described taking apart and doing financial estimates on the Toyota's new hybrid gas-electric automobile.

We also learned of several useful techniques for managing the risk associated with disruptive technologies. Siemens explicitly allocated a fraction of R&D funds for higher-risk projects, expecting a large number of failures but hoping for significant payoffs from the occasional successes. Siemens and Philips also used internal venture capital funding to encourage entrepreneurial risk-taking in internal incubator programs. In some cases, if the technical needs were inconsistent with core corporate strategies, Siemens sometimes would foster spin-offs or fund other start-up companies. Similarly, we note that CSR is on the receiving end of significant direct investment by a number of major international firms that believe CSR's clearly disruptive technology is strategically important.

Another common approach to dealing with the risk and cost of disruptive technologies was participation and funding of universities and collaborative forward-looking think tanks such as IMEC and Eurescom. Both institutions undertook R&D projects aimed beyond the next several generations of technologies and also did forward-looking market trends analysis and road mapping. The forward-looking work often involves broad representative groups from customers, suppliers, related industries, and universities in addition to the core firms. Because this work was considered pre-competitive, both IMEC and Eurescom tried to distribute their findings openly and widely through papers, journals, and conferences. On a related note, several firms also regularly scan the academic literature, fund PhD theses, and monitor other internal, more basic science to maintain strong contact and access to emerging ideas. However, the trends in the R&D activities of the corporations uniformly seemed to be away from basic science and toward much more applied work.

Several of our visits were with firms clearly comfortable with the role and risk of being the source of the potential disruption (e.g., Philips, CSR, ARM, ASML, and IMEC). However, another approach intended to limit the risk was to be a fast follower. For example, BASF characterized it as "wait, watch, and spend lots." BASF has concentrated on taking advantage of its scale, scope, and financial muscle, rather than spending the significantly more risky resources on being first.

On the sub-topic of managing individual projects involving potentially disruptive technologies, we did not sense that the processes were different from more traditional projects, although some cases had additional levels. Siemens, Frontier Design, and SAES Getters all established formal business processes for forward-looking projects; and, although these involved an additional level of decision making, they included familiar techniques such as evaluation and used familiar metrics such as likelihood of success, potential earnings, cost-benefit forecasting, and so forth. SAES Getters also had a formalized process for aligning individual projects with the broader strategic vision of the firm. At the project management level, the most noticeable difference when the project involved disruptive technologies was the formal internal incubator programs at Siemens and Philips, both managing them more independently as entrepreneurial businesses and formally recognizing that spin-out is a likely outcome. We note that internal venture capital funding is an increasingly common approach in the US as well.

In conclusion for Topic 6, we took away a clear sense that no magic formulas exist for dealing with, developing, marketing, or forecasting disruptive technologies. We also learned clever alternative approaches such as modular design at ASML, allowing replacement and upgrading of sub-units rather than entire systems, and encouraging incremental innovation further. Most significantly, in exploring disruptive technologies, we reinforced our perception of the critical strategic importance of Topic 4 on networks and partnerships and our own companies' needs to better leverage such partnerships.

The following excerpts from the participants' notes on some of the site visits reflect additional reaction to Topic 6.

Philips Consumer Electronics

Philips employed a number of techniques for dealing with disruptive technologies. The business units regularly prepare product roadmaps so the more central R&D groups can envision emerging opportunities. Philips also tries to bring new ideas regularly from research directly into the company. New PhDs were brought into the research laboratories and later moved into other parts of the company, often into product development groups. They bring leading-edge knowledge with them.

When Philips identifies an emerging technology, managers question whether they can develop it in house, or more effectively buy it in, through equity stakes. For example, Philips is strong in technologies related to digital video disk (DVD) and CD, but Philips buys shares in competence externally in areas such as sound or software.

Philips' experience is that consumer acceptance is a major commercial issue with disruptive technologies. New products with new technologies must be familiar/similar to existing consumers, including the whole package of ancillaries and complementary products. For example, Philips' CD/Interactive was too early to market in the 1970s. Storage capacity was like that of CDs not DVDs, nor did screens have sufficient high definition at that point. Those technologies were ready in the 1990s and now are now bringing DVD/Interactive. Laser video was also too early in the 1970s. It did just what DVD does functionally, but complementary technologies are better suited for commercial acceptance now. DVD/Read-Write (RW) is coming out now and will certainly find acceptance since CD/RW has been a hit and DVDs have become popular. The familiarity is far better.

Philips does have problems looking to existing markets for future ideas, since existing customers tend not to drive technology change. This is less true in Japan, where more prototypic products are put forward, then eliminated at various stages if customers are uninterested.

ASML

ASML is investing in exploring disruptive technologies, but not directly: it has only two people dedicated to basic research. Instead, ASML relies heavily on networks, alliances, and consortia to do much of the work in this area. Further, ASML is considering these disruptive technologies at the business strategy level. The limits of lithography are approaching, with fewer tricks left to continue the required improvements in size and speed demanded by the marketplace. ASML recognizes it must find new technologies, new markets, and new business models to sustain its growth rates and even to simply remain in business. Managers characterized the markets as "grow and eat, or stifle and be eaten." Best-in-class management of a broad innovation network was its core advantage. The company also designed its systems as explicitly modular. This flexibility at the sub-system level reduced the risk of potential future disruptive technologies from both ASML's and its customers' point of view, given the large investments required in buying leading-edge photolithography equipment.

Frontier Design (now Adelante Technologies)

Frontier has found that architectural-level hardware design is highly productive, but it is a radical technology. Frontier and other EDA vendors have found it very difficult to sell to others solely as an EDA tool. So the company has had to find a business strategy that leverages the disruptive technology but gets around customer uncertainty in using it.

Rather than abandon the technology or spend large sums to promote it and educate its customers, Frontier makes money by using the technology to do custom designs for customers. The advantages of the technology allow Frontier to be highly competitive in doing this. By focusing on related projects and leveraging custom work into standard cores, which Frontier can maintain as IP, it has created a profitable business model when others simply sell a product. This business model is now generating so much initial profit and IP value that Frontier may not revert to its EDA tool focus.

IMEC

IMEC's main mission is to do the R&D that might be in the intermediate-range future marketplace (3–10 years out). So, IMEC's activities are largely in the realm of potentially disruptive technologies. As mentioned earlier, IMEC has a unique business model of developing IP through forward-looking collaborative research programs and facilitating the sharing of emerging technologies exclusively through worldwide networking and partnering. Through the IMEC Scientific Advisory Board, officials work closely with industry and universities to develop a roadmap of longer-range industry needs, then undertake R&D along the farther reaches of that roadmap.

Cambridge Silicon Radio

CSR has leveraged its position as the disruptor into a means for getting start-up capital from equity investments by large firms that want access to it for strategic reasons. As we noted in Topic 1, we will watch with interest, as CSR must move from its extraordinarily successful start-up mode with leading-edge single-chip technologies that themselves disrupt established markets, into a more mature phase, trying to anticipate and leverage future disruptions. Its staff is currently somewhat limited to a near-to near-intermediate term focus.

Siemens

Within Corporate Technology, Siemens has formed an innovative business team. Small teams (~6 people) are removed from day-to-day R&D to bridge the gap from technology to business and look for new business. This team is responsible for developing scenarios of possible futures in five areas (health, information and communication, energy, industry, and transportation) out to the year 2010. Society, politics, economy, environment, technology, customers, and competition influence all of these areas. Siemens personnel have considered the trends of a more mobile workforce, the need for life-long learning, an aging population, the globalization of business, and a change to an information society. These scenarios provide ideas for new markets, customer requirements, applications, technologies, and what new core competencies must be developed for the future. The material has been well received so far and Siemens' credibility is increasing. People are coming to Siemens for consultations.

Corporate Technology maintains a network with other companies and universities to monitor upcoming technologies and ideas. Siemens' incubator program provides everything from office space to ideas that could add value. Contacts with venture capitalists are provided if the idea can be spun off instead of staying within the company.

Eurescom

This topic was not discussed that much at our Eurescom meetings, but Eurescom personnel did say that potential disruptive technologies were identified in the collaborative discussion process among shareholders of developing the research themes that guide the selection of projects. Eurescom sponsors projects that develop roadmaps and 7–10 projects annually that look forward at various technical areas, and that may identify where disruptive technologies are emerging.

BASF

BASF managers thought that change came relatively slowly in BASF's principal businesses. They have not seen large disruptive technologies in the last 10 or more years. Occasional process technology change occurs, but this is generally more incremental than disruptive to core business strategies. For product change, BASF is a fast follower, ideally letting others take most of the innovation risks, and leveraging the scale and scope advantages of BASF's size and integrated *Verbund* to dominate markets after they emerge, rather than pushing their emergence.

Renault Technocentre

Renault elects not to do much basic research. Although personnel do some applied research, the company primarily focuses on systems integration. So, disruptive technologies were not a major issue at the systems level. The 10 to 12-year lifetime of cars and the service aftermarket also limit Renault's ability to implement very radical systems. On the other hand, subsystem disruptions were possible, but consumer acceptance was an issue, and anything new had to be compatible with existing infrastructures like roads and service stations. Because the basic system is the same, the customers do not really buy technology, *per se*, and do not care if a subsystem uses a disruptive technology. Instead, they want performance at attractive prices. So, prototyping of concept vehicles was important. Indeed, the lobby of the Guyancourt facility served as a showpiece concept-car museum. These cars exemplify new technologies, very often potentially quite disruptive ones at the sub-system level. We mentioned to hour hosts that concept cars at auto shows very often get considerable press in the US, and Renault agreed that managers could get highly useful feedback that way, both positive and (sometimes brutally) negative, from consumers about the appeal of various ideas. Renault also used reverse engineering of competitors' products to try to understand the likely impact of disruptive technologies. For example, they described taking apart and doing financial estimates on the Toyota's new hybrid gas-electric automobile.

Saint Gobain

This topic was not discussed in great detail. We did discuss several of Saint Gobain's innovations and products, which gives some insight into its position on disruptive technologies. Saint Gobain seems to operate with a good balance of market pull and technology push. Several of its innovations have resulted in very interesting products or product concepts for which no strong markets yet exist (technology push). However, most of the company's key products seem to fill particular well-established market needs (bottles, glass, pipes, insulation) and its innovative activity is generally—although with several notable exceptions—incremental rather than breakthrough, despite its legacy as a fundamental technology disruptor to mirror making in the 17th century.

SAES Getters

SAES Getters is also impressive in the amount of thought given to disruptive technologies in both business strategy and R&D investment. Managers realize their corporate specialization is highly dependent on the continued viability of technologies like the CRT display. Knowing that substitutes for displays are being developed, SAES Getters works to find other markets for its basic competence and to expand current competence in other areas.

So, new growth in disruptive areas is very important to this company. It gets involved in designing components for the new niche markets. This involvement aids continued revenue growth, as it essentially creates an ongoing series of little monopolies for SAES Getters in those new technologies. Managers consistently analyze and monitor changing business needs and opportunities, and projects are selected or based on standard business criteria such as estimates of the likelihood of success, profit margins, demand forecasting, etc. The decision-making procedure takes place several times a year in a formal cycle.

D. Conclusions

To summarize the ISM experience and the various topics we explored, we conclude with our most lasting impressions. First and foremost, we compared our impressions with those of participants in the previous NTU ISM to Europe two years before and observed a significantly more vibrant energy among the hosting organizations than did the prior group. Perhaps it is because we explicitly visited some successful entrepreneurial start-ups; but even at large firms such as Siemens, ASML, Saint Gobain, and ST Microelectronics we sensed more spirit and a more positive outlook about the competitive position of European business in world markets. Many of our hosting institutions are legitimate world leaders, and they are unencumbered by attempts to catch up, which the previous group sensed during informal conversations with their hosts.

Similarly, the previous group scored European entrepreneurship very low in 1999, actually writing that their "overall impression was that entrepreneurship is neither respected nor encouraged in Europe" and of a "generally negative climate for entrepreneurship." Our impression was quite different. The Cambridge and Leuven areas are remarkably vibrant entrepreneurial environments, and our hosting firms—from huge Siemens and FT to mid-sized SAES Getters and small Frontier Design, through think tanks like IMEC—all had entrepreneurial processes in place, including support funding for internal incubation and spin-offs. Although overall venture capital and entrepreneurship still seem to lag in the EU compared with the US, the gap is clearly and rapidly narrowing.

Second, in our view, the firms seemed to take the now well-emerged EU environment and policymaking bodies almost for granted. Perhaps the EU generally represents very limited fractions of corporate R&D budgets and the EU has been making incremental progress for decades now. In retrospect, we speculate that the disinterest might in fact be a very healthy sign of how well established the EU institutions and regulations have become in the fabric of European business. A similar topic aimed at managers in our US companies about US government institutions and industrial policy might similarly generate only limited discussion because—except for defense contractors or in cases like the Microsoft antitrust suit—we also take for granted our government's significant role in helping US business operate efficiently.

A third lasting observation was Siemens' efforts to improve the link between long-term R&D and business strategy. We found very appealing its process and comprehensive vision of the future evolution of everyday life and technology and admired that company's success in working its vision into every corner of the company. This vision not only guides the expenditures in central R&D (long term, basic, and applied research), but also in the operating divisions, which understand the vision and are influenced as well. We mentioned earlier that this was similar to the future visions of our US companies, but Siemens appears more effective in communicating its vision than many of our firms.

Fourth, we reiterate that we were impressed by the process at ST Microelectronics both of sincerely valuing diversity and of developing and maintaining a cohesive corporate culture. The management team focuses on corporate culture rather than geography or background. More than our US firms (our rhetoric notwithstanding), ST Microelectronics managers truly respect the diversity that their worldwide organization can offer and the diverse nature of the global marketplace. And it pays off. As that approach has taken hold under the current corporate leadership, St Microelectronics has moved from the second tier to being a major force in world semiconductor markets. We now remain scratching our collective heads, trying yet unsuccessfully to envision a process for fostering such effective cohesive cultures in our own organizations.

Fifth, we note with interest that both Philips and Renault have actively moved away from distributed innovation activities, both organizationally and physically. Philips was constructing and Renault had constructed far more centralized R&D campuses, bringing together what had been more dispersed activities. They believe these campuses will be more efficient operationally, but these campuses may also facilitate better cross-discipline and cross-project communications, particularly for tacit knowledge. Technology transfer and communication were clearly a contact sport for Philips and Renault. Both firms also saw these central campuses as a more attractive, energetic places to work, helping to attract and retain the best technical talent.

Finally, we note again our lasting impression of how critical partnering and networking has become for all the host institutions, and, on reflection, for our own companies. Significantly, we took home with us a vision of a world-class example of a networked company from ASML, now the world's leading semiconductor photolithography equipment maker. ASML focuses on its core competencies of systems integration—integrating what it considers the world's best competencies in imaging (Zeiss), stage mechanics (Philips), and metrology (Agilent). ASML seems highly effective in utilizing the core competency model—outsourcing that which other companies do better (as opposed to outsourcing that which they just don't want to do, or don't feel is worthy of doing in house). But beyond simple outsourcing, ASML invests heavily in creating, nurturing, and managing these key partnerships.

We are sincerely thankful for the willingness of our European hosts to share their time and ideas with us. We hope they can understand how much we value the help they have given us to grow both personally and collectively as international colleagues in technology management.

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APPENDIX A: OBJECTIVES AND ITINERARY

The purpose of the National Technological University (NTU) Management of Technology (MOT) Program of 2001 International Study Mission is to provide an intensive learning experience that will enable the participants to gain first-hand understanding of European technology management practices in a variety of countries and industries, to learn more about European economic cooperation and integration, and to explore some aspects of European history and culture.

The 2001 International Study Mission will emphasize opportunities for the participants to engage in mutual discussions about issues and topics that are relevant to contemporary business and government situations in several European countries, as well as in the United States. In this respect, the goals are similar to the previous Study Mission trips to Europe in 1999, Japan in 1993 and 1995, and the 1997 trip to both Japan and Korea. As in the past, the participants in the 2001 International Study Mission seek an open exchange of views on important issues that technology managers are likely to face as global economic development continues into the next decade.

The team members in the 2001 Study Mission are technical managers working in major US industrial firms and government laboratories and enrolled in an Executive Master's of Science program at NTU using satellite-based distance learning. The team members will be accompanied and led by MOT faculty members. (See *Study Mission Team* list.)

During the 2001 International Study Mission, the team members will visit companies in Northern, Central, and Western Europe, where they will meet with representatives to discuss technology management practices in various industrial and business settings and exchange views on European and US practices. For example, the Study Mission teams will visit the following types of companies:

- an Industrial R&D laboratory
- an Electronics/Telecommunications company
- a Consumer Products company
- a small company with global position

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The 2001 International Study Mission team members will have an opportunity to—

- understand current economic conditions in several European countries, as well as the challenges for European Community cooperation and integration;
- learn about the European systems for R&D and technological innovation;
- become more familiar with the role of the government in several European countries, and the role of the European Community structure, in support of global economic development and technological innovation;
- initiate professional and social networking with technical managers in European companies; and
- experience European culture in several countries and explore personal interests through travel and social activities.

The 2001 International Study Mission objectives will be accomplished through lectures, company site visits, and informal discussions. While in Europe, the Study Mission team will visit 12 industrial companies; will participate in three seminars; and will travel and experience European culture in several locations. An initial report and presentation of the Study Mission findings will be done at the conclusion of the Study Mission in Europe, before the team members return to the US. The final report will be distributed after editing and completion in the US.

The 2001 International Study Mission group includes:

- 1 MOT faculty leader
- 11 technical managers/graduate students
- 1–2 guests (industrial managers)
- 1 support staff person

Study Mission Leadership

Faculty Leaders: Professor Todd A. Watkins will lead the 2001 International Study Mission.

Team Leaders: Study Mission participants will assist with communication in advance of the Study Mission, work with the Faculty Leader during the site visits, and provide assistance on logistics during the travel periods. All participants will be asked to help with the final report preparation after return to the US.

Team Members: Each team member has participated in the preparation of topics for discussion, has attended work sessions to prepare for the Study Mission, and has done the assigned reading. All participants are expected to respond to communications in advance of the Study Mission, to notify the Faculty Leader of any relevant problems or information, and to actively participate during the Study Mission trip.

Study Mission Sponsors:

- National Technological University, Fort Collins, CO
- Center for Innovation Management Studies, North Carolina State University, Raleigh, NC
- Industrial Research Institute, Washington, DC
- European Industrial Research and Management Association, Paris

APPENDIX B: TOPICS FOR DISCUSSION

Topic 1: EU Business Environment and Government Policies
Every country and region has its own business environment, with relative strengths and weaknesses in technology and business performance.

- What do you consider to be the technological strengths and weaknesses in Europe that are relevant to your firm's principal businesses? What are the technological strengths and weaknesses of your industry, university system, national government, and EU institutions? How do you exploit these strengths and compensate for these weaknesses in MOTI?
- Which national and/or EU policies and institutions have the most significant effect on MOTI in your firm? Why? (e.g., EMU? EU regulatory harmonization? R&D subsidy programs? Privatization of nationally owned firms? Intellectual property/patenting? Tax/fiscal policy? Capital market structure? Social welfare policy? Labor unions? Government organization? Industrial policy? Long vs. short time horizon? Others?)
- What business and technology approach are you taking with respect to recently democratized states in Eastern Europe? What impact if any do you foresee as EU membership expands?

Topic 2: Strategic Direction of R&D/MOTI
Effectively managing the R&D function and the technological innovation process in the firm requires a close integration with competitive/business strategy.

- How does your firm ensure that the R&D function is being managed in a way that it effectively supports your competitive/business strategy? What are the linkages that you have created between R&D and competitive/business strategy and what processes do you use to identify and pursue strategic opportunities?
- Do you use any *portfolio management* concepts or techniques in managing the range of projects and programs in the R&D function? If so, what has your experience been?
- In developing an *R&D Portfolio* of programs and projects, how much emphasis do you place on *technology drivers* as opposed to *market drivers*? [I.e., to the potential inherent in the technology (*technology push*) as opposed to the potential opportunity in the market (*market pull*)?]

Topic 3: Managing Decentralized Operations
As more firms decentralize R&D and manufacturing operations around the world, managing a coordinated and coherent program of research and new product/process development becomes more difficult and more complex.

- Does your firm have significant R&D operations in other countries? If so, where and why?

- How do you determine what R&D should be done with what resources in each location? What processes do you use to exert control and to coordinate decisions about staffing and funding at each location?
- How do you measure and reward R&D productivity and performance?
- How do you organize, integrate, and allocate project responsibilities among geographically dispersed new product development teams? What technologies, collaboration tools, methods, or mechanisms do you use for communication among project team members?
- How are e-services changing your internal processes, your products, or new product introduction cycles?
- In managing R&D globally, how do you deal with gender, racial, national, and cultural differences in which foreign values, practices, and customs are much different from your own?

Topic 4: External Technology Acquisitions Through Networks, Alliances and Acquisitions

As technology is increasingly being acquired from external sources, as well as being developed internally, firms are becoming more active in technology-motivated networks and alliances and in mergers with and acquisitions of other firms.

- Is your firm active in networks or alliances to develop technology, or has it acquired or invested in other firms for the purpose of obtaining its technology?
- If so, how do you select the firms you partner with, acquire, or invest in? Why do you seek the technologies externally rather than developing them internally?
- What methods do you use to ensure your firm can efficiently access, internalize, and use these external technologies?
- How does your firm manage external relationships with regard to establishing goals and responsibilities, resolving conflicts, and ensuring effective communication?
- How do you cooperate with competitors in such alliances/networks?

Topic 5: Managing Human Resources in High-technology Firms

The knowledge assets of a firm are increasingly being recognized as a strategic resource that is embedded in the scientific and technical work force. In the United States, there is a shortage of scientists and engineers and a tradition of career mobility (leaving one firm and joining another) that is of great concern to high-technology companies.

- Do you have the same demographic problem of a shortage of scientists and engineers and in retaining your company's scientists and engineers?

- How does your firm identify, recruit, and retain scientifically and technically skilled people? How do you motivate, reward, and promote them? Do these practices apply to all professional employees, or are they special to scientists and engineers?
- In what way is your firm or industry working with schools and universities to ensure a continuing supply of skilled scientific and technical talent?
- Have EU labor mobility efforts had any significant impact on your company?

Topic 6: Dealing With Disruptive Technologies

In the United States, high-technology firms are concerned with the management of disruptive technologies, technologies that disrupt an established business trajectory or redefine what performance means for a product or product line.

- Does your firm recognize disruptive technologies or radical/discontinuous innovation as being of special interest or importance?
- If so, how do you identify opportunities and encourage its development? How do you deal with its inherent risk and uncertainty? How do you achieve balance in the allocation of effort between them and the more incremental or sustaining technological developments?
- Do you manage projects to develop disruptive technologies differently than other development projects? If so, how?
- How do you respond to the development of disruptive technologies by competitors in your principal businesses?