National Technological University

Management of Technology Program

Management of Technology in Europe 2003: Comparing Strategies and Tools in 17 High Technology Organizations

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EXECUTIVE SUMMARY

From May 9-22, 2003, NTU's MOT class of 2003 visited 17 high technology organizations and met with more than 50 senior R&D managers (e.g. VPs, Directors, CTOs) in five European countries, to explore how they manage their innovation activities. It was a rare opportunity to engage this level of management and gain their perspectives on technology management.

As with previous Study Missions to Japan, Korea and Europe, our host organizations 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 fortunate to have been so well received.

The 2003 MOT Study Mission had as its primary focus management of technology and innovation in Europe, with a specific focus on external relationships. The context of these relationships was activities that entailed collaborative research, co-development of products, outsourcing elements of the innovation or technology lifecycle, manufacturing, sales, distribution and/or customer relationships.

The focus 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. Given the economic climate, there was particular urgency to make sure that efforts were focused on what each company did best. DaimlerChrysler accomplished this communication and alignment by cascading objectives down through the organization. Smaller organizations such as SAES Getters had long-term strategic plans that all employees understood. Second, portfolio analysis and stage/gate methods are being widely accepted as the tools of choice for selecting and tracking R&D projects. These tools add structure for driving the strategic vision into bottom line results. Even with an impressive mastery of these methods, European firms, like their American counterparts, struggle with making the right strategic choices. (*See Section 6B, Topic 1 for details.*)

The second topic was **external technology acquisitions through networks, alliances, and acquisitions**. 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 DaimlerChrysler, Fiat 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.

ASML in particular stood out for its effective strategic use of networking. 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, ultra-high precision mechanics and materials. STMicroelectronics' 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. MEDEA+ stood out for its ability to facilitate collaboration between many different companies with a very small staff. (*See Section 6B, Topic 2.*)

Third, we explored issues in **managing 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. STMicroelectronics, in particular, deploys a potential-vs.-contribution matrix, a 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 is 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 with the EU expansion eastward. We also noticed a wide variation among firms in the degree of multinationality in the workforce, with Schlumberger standing out with an explicit strategic emphasis on a particularly mobile and internationally diverse workforce. This attention to diversity seemed clearly positively correlated with the palpable sense of a highly innovative environment there. Finally, we note the strategic use of attractive, campus-like environments at Philips, CERN and Eurescom, in part to facilitate attracting and retaining the best talent from around the world. (*See Section 6B, Topic 3.*)

The fourth 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. 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 Philips recently became more centralized by relocating into new central R&D facilities—a university-like campus for Philips. CERN had impressive processes and technologies for managing and distributing huge volumes of technical information. Two visits were 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, and MEDEA+ performs a similar coordinating role for joint semiconductor research. (*See Section 6B, Topic 4.*)

Our final topic 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 fostering labor mobility and infrastructure and in enabling standardization, which is often critical in high-technology industries. 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 6B, Topic 5.*)

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 the European Industrial Research Management Association (EIRMA), specifically Secretary General Andrew Dearing for facilitating our visits to EIRMA members. A heartfelt thanks particularly goes to Dr. Nico Hazewindus, formerly of Philips, who developed the itinerary and who deserves full credit for the great success of the Study Mission. Finally, we are principally and deeply 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 2003 International Study Mission.

MOT Faculty, Staff and Students Class of 2003

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; and teams went to both Europe and Asia. The 2003 Study Mission focused again exclusively on Europe. Preparations began in the fall of 2002 and on May 11, 2003, students and faculty, met in Milan, Italy. The trip ended on May 22, 2003 in Paris.

This report highlights the goals and objectives of the trip and reports on what the participants learned. It will be distributed to everyone who participated in the Study Mission 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 principal findings of the members who participated in the study mission. Section 6A presents a brief profile of each organization visited in Europe, which team members prepared in advance. Section 6B 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:

- Strategic direction of R&D/MOT;
- External technology acquisition through networks, alliances and acquisition;
- Managing human resources in high technology firms;
- Managing decentralized operations;
- EU business environment and government policies.

The Study Mission findings were based on the reports of team members during the trip. This report is the product of the entire Study Mission 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 2003 International Study Mission 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 Study Mission held meetings with senior executives and managers from a variety of large and small European firms from several different industries in Germany, France, Italy, Switzerland 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 Study Mission trips to Europe in 1999, to Japan in 1993 and 1995, to Japan and Korea in 1997, and to Europe and Asia in 2001. As in the past, the participants in the 2003 Study Mission sought an open exchange of views on important issues that technology managers confront as global economic development continues in the next decade.

The Study Mission teams visited 17 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, chemical and materials firms and two automotive manufacturers giving broad perspectives across industries and geography. The participants also had the opportunity to explore European history and culture through group tours and housing in historical areas of the host cities.

The 2003 Study Mission team focused on the following objectives:

- Explore best-practice strategies and tools for managing technology and innovation in European organizations;
- 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;
- 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 TEAM

The team members in the 2003 International Study Mission were technical managers in major US industrial firms 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.

Faculty Leader:

Dr. Todd A. Watkins	College of Business and Economics, Lehigh University, Bethlehem, PA

Team Members:

Mr. Dominic Busher	IBM, Tucson, AZ
Mr. Paul Carau	Hewlett-Packard Company, Ft. Collins, CO
Mr. Josea Dossantos	IBM, Tucson, AZ
Ms. Patty Kummrow	Hewlett-Packard Company, Ft. Collins, CO
Mr. James Nottingham	Hewlett-Packard Company, Boise, ID
Mr. James Procopio	IBM, Burlington, VT
Mr. James Taber	Agilent, Santa Rosa, CA
Mr. David Thomas	Hewlett-Packard Company, Corvallis, OR

European Coordinator:

Dr. Nico Hazewindus	International Technology Policy Consulting, Heeze, NL

5. STUDY MISSION SCHEDULE

May 11	Convened in Milan for MOT Residency activities and Study Mission briefings.
May 12 - 13	Fiat Research Labs - Turin Telecom Italia Labs - Turin SAES Getters - Lainate STMicroelectronics – Agrate *Travel to Geneva*
May 14	CERN Hewlett-Packard
May 15	*Travel to Stuttgart* DaimlerChrysler
May 16	*Travel to Heidelberg* Eurescom *Travel to Darmstadt* Merck
May 17	*Travel to Amsterdam with stop to explore Cologne*
May 18	Explored European history and culture in the Amsterdam area.
May 19	ASML – Eindhoven Phillips Research – Eindhoven
May 20	*Travel to Delft* TNO *Travel to Vlaardigen* Unilever *Travel to Paris*
May 21 - 22	Saint-Gobain Total Schlumberger MEDEA+ Office
May 23	Departed Paris

6. STUDY MISSION RESULTS

A. Profiles of Organizations Visited

In Milan, the Study Mission 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 14 high technology companies and three other technology-industry related organizations. The team had prepared five topics in advance for discussion (see below and Appendix B) and forwarded them to each company. During the Study Mission visits, discussion focused on topics the host companies had chosen from among the five. 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 17 organizations during the Study Mission visits, but it is worthwhile to present a brief profile of each company before reporting the results of the discussions.

NTU's MOT class of 2003 met with more than 50 senior R&D managers (e.g. VPs, Directors, CTOs) to explore how they manage their innovation activities. It was a rare opportunity to engage this level of management and gain their perspectives on technology management.

The European team visited the following companies and organizations, listed here in alphabetical order. Brief profiles of each follow, in alphabetical order.

Companies:

- ASML, Eindhoven, The Netherlands
- DaimlerChrysler, Stuttgart, Germany
- Fiat Research Labs, Turin, Italy
- Hewlett-Packard, Geneva, Switzerland
- Merck, Darmstadt, Germany
- Philips Research, Eindhoven, The Netherlands
- SAES Getters, Lainate, Italy
- Saint-Gobain, Paris-La Defense, France
- Schlumberger, Paris, France
- STMicroelectronics, Agrate, Italy
- Telecom Italia Labs, Turin, Italy
- TNO, Delft, The Netherlands
- Total, Paris, France
- Unilever, Vlaardigen, The Netherlands

Other Organizations:

- CERN, Geneva, Italy
- MEDEA+, Paris, France
- Eurescom, Heidelberg, Germany

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

ASML Holding N.V. provides advanced technology systems for the semiconductor industry. The company primarily designs, manufactures, markets and services semiconductor-processing equipment used in the fabrication of integrated circuits. With 2002 revenues of €2.0 billion and 5200 employees, ASML in 2003 is number one worldwide in lithography systems, holding more than 50% market share. Founded in the Netherlands in 1984, ASML offers an integrated portfolio of lithography systems mainly for manufacturing complex integrated circuits. The company supplies systems to integrated circuit manufacturers throughout the United States, Asia and Western Europe, as well as provides a full range of support from advanced process and product applications knowledge to service support. ASML's photolithography equipment includes Step & Scan systems, which combine stepper technology with a photo-scanning method.

Study Mission Hosts:

- Jan William E. Bos, Director Resources, Human Resources
- Michiel Evers, Human Resource Advisor
- Mariëlle Verberne, Human Resources & Organization Resource Center

CERN, Geneva, Switzerland, www.cern.ch

CERN, the European Organization for Nuclear Research, is the world's leading and largest particle physics research laboratory. With an annual budget of €600M and directly employing 3000 people, CERN provides researchers worldwide with the tools necessary to perform particle research, primarily accelerators, particle detectors and data management tools. Fully half the world's particle physicists, 6500 scientists from 500 universities and 80 countries, use CERN facilities or the data collected by the various detectors. The equipment they need to advance understanding the composition of particles is so costly that it requires international collaboration to share the expense. The information sharing needs of this collaborative network led a CERN scientist to invent the World Wide Web. Founded in 1954, CERN has 20 Member states, plus 9 observer states/ organizations and 28 non-member states.

Study Mission Hosts:

- Dr. Hans F. Hoffmann, Director for Technology Transfer and for Scientific Computing
- Sonia Escaffre, Secretary to Dr. Hoffmann
- Dr. Francois Grey, Open Lab Development, IT Division
- Dr. Florian Sonnemann: Strategic Planning Officer, Directorate Services

DaimlerChrysler, Stuttgart, Germany, www.DaimlerChrysler.com

DaimlerChrysler's principal activity is the manufacture and distribution of automobiles and trucks. Additional products and services include diesel engines, helicopters, aircraft, space and defense systems, vehicle financing services, electric and electronic engineering services and insurance brokerage. The result of a 1998 merger, DaimlerChrysler employed 365,600 people at year-end 2002 with revenues of €149.6 billion. The Chrysler group accounted for 40% of 2002 revenues, Mercedes group 31%, commercial vehicles 18%, and services 11%. The €6 billion research and development budget at DaimlerChrysler includes 28,000 employees and is currently focusing on traffic safety, CO2 emissions reduction, and new vehicle development..

Study Mission Hosts:

- Dr. Horst Soboll, Director, Research Policy and Communications
- Dr. Gösta Pfundtner, Research Policy and Communications

Eurescom, Heidelberg, Germany, www.eurescom.de

The European Institute for Research and Strategic Studies in Telecommunications (Eurescom) is Europe's leading institute for collaborative telecommunications R&D. European telecommunications network operators and service providers established Eurescom in 1991 to facilitate research of joint interest and these firms comprise Eurescom's primary shareholders. Eurescom works essentially as a collaborative R&D management services company. Its mission is to provide efficient management of research projects and programs for member companies and other clients (mostly in Europe). Decentralized teams of experts conduct project work in their own facilities, but projects are supervised and coordinated by Eurescom staff. A core team of 20 permanent staff manages about 40 to 50 projects annually amounting to over €50 million.

Study Mission Hosts:

- Dr. Claudio Carrelli, Director
- Milon Gupta, Public Relations Officer

Fiat Research Labs, Turin, Italy, www.fiatgroup.com

Established in Turin in 1899, Fiat was one of the founders of the automobile industry. The Fiat Group's automobile operations include the Fiat, Alfa Romeo and Lancia brands. Fiat also controls Ferrari and Maserati, which manufacture luxury sports cars, and has a Commercial Vehicles group. Fiat currently employs over 223,000 people (about half of them outside of Italy) and generates revenues of over €57 billion. Fiat's research and development activities, including, in Turin, one of the leading centers of automotive design, focus on safety and style in new products.

Study Mission Hosts:

- Dr. Ing. Luciano Pera, Executive Vice President, Research Promotion
- Gianni Mora, Director, Business Information Technology
- Andrea Campiglia, Human Resources
- Paola Carrea, Central Research
- Paola Cielo, Research Promotion
- Luca Olivetti, Director, CFO

Hewlett-Packard, Geneva, Switzerland, www.hp.com

Founded in 1939, Hewlett-Packard has become a world leader in home and office technology including laptops, desktops, servers, software, scanners, printers, and digital cameras as well as financial and other business services. After a May 2002 merger with Compaq, HP now boasts 140,000 employees and FY2002 revenues of $72 billion. The central research organization, HP Labs, expends $4 billion annually. HP's rate of innovation included over 100 new products and 140 patents in the second half of 2002. The HP Geneva site visited is a field office, not an R&D organization.

Study Mission Hosts:

- Bernard Meric, Senior Vice President, Imaging & Printing Group
- Linda Keita, Imaging & Printing Group

MEDEA+, Paris, France, www.medea.org

MEDEA+ (Microelectronics Development for European Applications) is the industry-initiated pan-European program for advanced co-operative R&D in microelectronics. With R&D in microelectronics being a high-risk investment with significant time-to-market and time-to-volume pressures, MEDEA+ attempts to reduce the risk by enabling pre-competitive R&D in areas of general interest. Similar to the original SEMATECH consortium in the US, the intent is to keep European companies competitive in microelectronics. Currently, 2,600 scientists and engineers from almost 220 partners are working on 34 different advanced research challenges at a cost of €500 million annually, culled from both partner and public monies. An eight-year strategic plan (2001-2008) focuses projects on both applications (e.g. high speed communication systems, integrated information/communication/entertainment, smart cards for secure internet, automotive electronics, and design methods) and supporting technologies (enabling integrated circuit technologies for applications, integrated circuit technology integration, other equipment, lithography, packaging).

Study Mission Hosts:

- Dr. Gerard Matheron, Director
- Otto Laaff, Communications Officer
- Jean-Pierre Noblanc, Chairman

Merck, Darmstadt, Germany, pb.merck.de

Founded in 1668, Merck has a long history in chemicals and pharmaceuticals and is now the world's top producer of liquid crystal materials. Pharmaceutical offerings include cardiovascular, diabetes, oncology, thyroid, consumer health products and generics. Chemical areas include electronics, reagents, pigments and life sciences. Merck KGaA is composed of 204 companies

operating in 53 countries. In North America, the company operates as EMD. (The US-based Merck & Co. was split from Merck KGaA after WW I and is a completely separate company.) The company enjoys worldwide sales of €7. 5 billion and employs 34,500 people. About 43% of revenue comes from pharmaceuticals, 21% from chemicals and 36% from the laboratory distribution business, VWR International, Inc. Merck spends €2.9 billion annually on innovation and research in pharmaceuticals and for higher grade products in the chemicals business.

Study Mission Hosts:

- Dr. Sigfried Neumann, Head, Office of Technology
- Dr. Michael Gerards, Office of Technology: Business Development
- Karsten Beutnagel, Director, HR

Philips Research, Eindhoven, The Netherlands, www.philips.com

Philips Electronics, the world's third-largest consumer electronics company, makes TVs, VCRs, CD and DVD players, phones, pagers and other electronic devices. 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% market share in analog television (TV) chips. With sales of €31.8 billion in 2002, the company employs 164,000 people in over 60 countries. Its brands include Marantz, Norelco and Magnavox. The company also makes light bulbs (#1 worldwide), electric shavers (#1), picture tubes, small appliances, electronic components, medical systems, PC monitors and semiconductors. Philips Research focuses on innovation in consumer and business technology and has about 2,500 employees in Europe, China and the US. 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.

Study Mission Hosts:

- Dr. Fopke Klok, Senior VP Philips Research, Director Planning & Programming
- Paul Fleuren, Senior VP Philips Research, 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% 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. SAES's 17 companies and more than 1000 employees generated sales of €141 million in 2002. Ten percent of this sales revenue goes to R&D focused on the company's core competencies of special metallurgy, vacuum and ultra-high vacuum technology, gas-surface interactions, ultra-clean gas purification and handling, and gas analysis and impurity monitoring.

Study Mission Hosts:

- Dr. Ing Paolo Della Porta, President & Group CEO
- Dr. Claudio Boffito, Deputy R&D Manager, Chief Metallurgist
- Sergio Carella, Human Resources
- Dr. Bruno Ferrario, Director, Group Research & Development
- Gabriella Rossi

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

Saint-Gobain is a major producer, processor and distributor of raw materials found in many of the products used in our daily lives. Founded in 1665 as a manufacturer of glass plates, its 17th century technological breakthrough was the ability to make very large glass panes, used to make mirrors. Now, nearly 340 years later, roughly 40% of the company's revenue remains in the glass business: the firm provides glass for 50% 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. It is a leader in most markets it is in: insulation (#1 worldwide), packaging glass (#2), flat glass (#3), building materials (#2), high performance ceramics and plastics (#1), ductile iron pipes (#1) and abrasives (#1). It is also #1 in Europe in the building materials distribution business. Saint-Gobain operates in 46 countries with a workforce of over 170,000 and 2002 revenues of €30.3 billion. Saint-Gobain spends about €300 million in R&D, employing 3000 researchers and technologists in the group's 16 research laboratories. These are complemented by a large number of smaller development units specializing in pilot projects and other activities with the main production sites. While most research centers are located in France, the Group also has several important centers in Germany, Spain and the United States.

Study Mission Host:

- Helmer Rädisch, Vice President, Human Resources and Program Management

Schlumberger, Paris, France, www.slb.com

Schlumberger is a global technology services company consisting of three primary business segments: Schlumberger Oilfield Services (OFS), WesternGeco and SchlumbergerSema. Schlumberger OFS supplies technology services and solutions to the international petroleum industry. WesternGeco, a joint venture with Baker Hughes, is the number one seismic imaging company. SchlumbergerSema is the information technology (IT) branch of the firm covering consulting, infrastructure and systems integration, managed services and related products for the global energy (oil & gas and utilities), telecommunications, finance and public sector markets. Both OFS and SchlumbergerSema offer IT services to provide network connectivity, information security, distributed computing support, data center hosting and business continuity services. The firm also has subsidiaries engaged in water services, smartcards and terminals, and semiconductor test and verification systems. The firm spent $650 million on R&D in 2002 from $13.2 billion in sales revenue, and had 78,000 employees in more than 100 countries.

Study Mission Hosts:

- Yves Morel, Marketing Manager, Schlumberger Research
- Sylvie Rancon, Personnel Manager

STMicroelectronics, Agrate, Italy, www.st.com

STMicroelectronics (ST) is the #1 Europe-based semiconductor manufacturer, #6 worldwide, and the world's #1 maker of analog chips. ST makes many types of discrete devices (such as transistors and diodes) and integrated circuits (ICs), including microcontrollers, memory chips, smart-card chips, and application-specific and custom ICs. The company sells to manufacturers in the telecommunications, computer, consumer electronics, industrial and automotive markets. STMicroelectronics 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. ST currently employs over 43,000 people and generated $6.32 billion in revenue in 2002. Their $1 billion R&D budget is focused on intensive product development, especially in close concert with key long-term strategic allies, through 16 worldwide research units that filed over 680 patent applications in 2002. STMicroelectronics is also active in numerous collaborative research projects worldwide and plays a major leadership role in

Europe's advanced technology research programs such as MEDEA+.

Study Mission Hosts:

- Dr. Ing Giuseppe Zocchi, Senior Vice President, Central R&D
- Livio Baldi, European Cooperation Programs Director, Central R&D
- G. Bettoschi, Human Resources
- P. Cappelletti, Director, NVM Process Development
- Hervé Grotard, Program Director, ST University
- P. Peruzzi, Human Resources
- Dr. Giordano Zanetti, Group Vice President, Corporate Strategic Planning

Telecom Italia Labs, Turin, Italy, www.telecomitalia.it

Telecom Italia is Italy's #1 fixed-line telecommunications operator and #1 wireless provider (through 55%-owned Telecom Italia Mobile). With 2002 sales of €30.4 billion, the company also holds stakes in telecommunications operations outside Italy, especially mobile phone carriers, mainly in Europe and Latin America. Telecom Italia Labs, the R&D branch, currently employs 1200 people and spent €156.8 million in 2002. Telecom Italia R&D focuses on telecommunication network and services innovation, design and prototyping, as well as on mid-to-long term research (in partnership with Pirelli Labs), and on testing activities. Note that after our Study Mission team visited in May 2003, Telecom Italia and the Italian IT conglomerate Olivetti merged in August 2003. All discussion below is based on our pre-merger visit.

Study Mission Hosts:

- Giovanni Colombo, Chief Technology Officer
- Giancarlo Pirani, Senior Project Manager

TNO, Delft, The Netherlands, www.tno.nl

The Netherlands Organization for Applied Scientific Research (TNO) is a private/public research initiative aimed at increasing the competitiveness of Dutch companies, the economy and the quality of society as whole, through scientific knowledge and innovation. R&D activities include supporting the development and utilization of knowledge in industry and government, and fostering technology transfer especially to small and medium-sized enterprises. Established by law in 1932, TNO also acts as a principal laboratory for ministry of defense and other ministries and promotes the commercialization of knowledge in cooperation with companies. Through research services, TNO's 5,500 employees generated an operating income from government and private sources of €534 million in 2002, about 10% of which gets reinvested in further developing leading R&D competencies. The group focuses on R&D in five core business areas: quality of life, defense and public safety, advanced product-processes and systems, natural and built environment and information communication technology (ICT).

Study Mission Hosts:

- Dr. C.L. Ekkers, Director, Strategy & Research Planning
- Aert C. de Geus, Manager Technology, TNO Bouw
- Prof. Dr. J.H.W. de Wit, Board of Management
- Geert Schoch, Director, International Projects, Commercial & Legal Affairs

Total, Paris, France, www.total.com

Total is now the world's fifth largest oil company, with 2002 revenues of €102 billion. It employs 122,000 people worldwide in three sectors of the petroleum market: upstream (exploration/oil production, which provides 11% of revenues), downstream (refining/marketing, 29%) and chemicals (59%). One of Total's emerging R&D foci is on bio-fuels, as a good

alternative source for transportation fuels. Total is the result of two recent mergers, first in 1999 between the French firm Total and the Belgian firm Petrofina, then in 2000 between TotalFina and the French firm Elf Aquitaine. TotalFinaElf changed its group name during the International Study Mission. The new name, Total, is used in this document.

Study Mission Host:

- Dr. Claude Jablon, Senior Vice President, Scientific Development

Unilever, Vlaardigen, The Netherlands, www.unilever.com

Unilever is the world's #1 producer of ice cream, margarine and tea-based beverages and is a major manufacturer of other food products, personal washes, prestige fragrances and deodorants. Overall, Unilever is the world's third largest food company. Its 265,000 employees generated a group turnover of €48 billion in 2002, selling products in 151 nations. Unilever's R&D strategy is to focus on its leading brands, that is, those that are most in demand from consumers. Leading brands include Knorr, Heart, Breyers, Igloo, Birdseye and Slimfast. Innovation is especially important to Unilever in personal/home care products in order to maintain a strong market position. The firm employs about 1200 in its central R&D centers and spends €1.2 billion on R&D corporate-wide, half in the five main research centers in the UK, Netherlands, India and China, and half in various global technology centers and regional innovation centers.

Study Mission Hosts:

- Dr. Jan de Rooij, Director, R&D
- Dr. Jan Maat, Principal Scientist, External Research

B. Results of Study Mission Discussions

In this section, we summarize the results of our discussions with the host organizations on each of the five 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 additional reflective excerpts from Study Mission team members' notes.

Topic 1: Strategic Direction of R&D and Management of Technological Innovation

In our technology-based US firms, we find effectively managing the R&D function and the technological innovation process requires a close integration with competitive/business strategy.

- How does your firm ensure that the R&D function is managed in a way that effectively supports your competitive/business strategy?
- What mechanisms do you use to identity emerging technology and business opportunities?
- How has your technology strategy changed in response to the significant worldwide slump in technology industries?
- Are disruptive technologies or radical/ discontinuous innovation of special interest or importance to your firm? How do you promote your own or respond to competitors' disruptive technologies?
- With particular focus on the management of technological innovation, do you see particular strengths in the way you manage your customer relationships?

Topic 1: Summary & Conclusions

Long term vision and strategy

The importance of developing a vision of the future and strategies to achieve that vision were major themes through all of our visits. The difficult economic climate, especially in high tech, has made this critical, as the natural tendency is to focus only on the short term. 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, and we appreciated the high degree of attention to these issues in evidence at nearly all our host organizations.

Schlumberger showed impressive ability to address both the short-term and long-term problems of their customer base. By looking at the immediate requests from oil producing companies, they could develop solutions/services with a quick return. At the same time, they looked at long-standing problems faced by the oil companies, and even anticipated potential problems and used those for developing long-term strategic direction.

DaimlerChrysler used a similar procedure with their long-range vision of how the world of automobiles would look in 20 years. This was turned into long-range technical challenges that set the direction for research, which was then cascaded down through the organization through an admirable process of engaging managers at all levels.

Saint-Gobain had an excellent understanding of who they are as a company and the types of markets within which they can compete. They do not define themselves as all glass, but rather as a source of solutions that customers will need for years to come. They recognize that they cannot compete in fast-paced markets, and therefore avoided the trap, so to speak, of entering the fiber-optic network markets.

STMicroelectronics uses Moore's law to steer their vision and supporting strategy. It is a simple model, well understood by all, that quickly and clearly communicates where development must go to remain competitive.

One challenge in creating and maintaining R&D strategy was determining how to link the strategy to customer value and to product viability in the market. Multiple firms across a broad spectrum of industries commented on the problem of understanding their market so that they could predict and fulfill customer needs. Unilever had come to terms with this by becoming brand-focused and reducing their total number of brands from 1600 to 400.

Another area of significant focus was on communicating and aligning employees around the strategy. DaimlerChrysler cascaded company objectives and strategy all the way down through the company to maintain alignment. Smaller companies such as SAES Getters had five- and ten-year strategic company goals that most if not all employees knew and could use to help determine appropriate directions. We were particularly impressed with how consistently understood and well articulated the corporate strategy was through all levels at SAES, STMicroelectronics and Unilever. After speaking with not only top and mid-level managers but also lab bench researchers at these firms, we wondered whether our own firms would have such consistency of vision from top to bottom.

Investments in R&D projects

Determining how to distribute R&D funds across long-term and short-term projects was another major theme. Given our own experience and toils in our US firms, it was somewhat reassuring to see that all companies struggle with technology management and their ability to leverage core competencies to top line growth. The approach used for each company was different depending on their business segment and organizational culture. It is hard enough in good economic times to justify spending money on riskier technologies, which have low or long-term commercialization prospects. It is even harder to invest in riskier technologies when shareholders demand a growing bottom line. However, creating the right mix of incremental, innovative and radical (blue, gray and white-space) opportunities with the available R&D budget seemed to keep the innovation engine alive in the firms we visited. We saw the best examples of this mix at SAES Getters, Merck, Unilever and Philips Research. These firms had a range of technology investments with varying levels of risk.

Most firms start with a basic rule for splitting funds between long-term corporate research and shorter-term product development. Virtually all the firms then used some sort of stages-and-gates process to track and control project progress for technology and new product development, though their implementations varied widely. The main differences among visited firms were in "who" gets involved "when." For instance, more innovative ideas tended to be screened by only a few, high-level individuals, though the inputs came from numerous sources. The early screeners tended to be senior technology managers with close ties to the business. One implication here is that the senior managers supported more innovative ideas. Those ideas, passing initial screens, then engaged broader groups, to balance technical innovation with financial return. Firms with too much structure before official project launch seemed to have fewer innovative ideas coming out of their labs (Fiat Labs' process while well documented, appeared to drive innovation activities rather than the other way around).

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. It does not set a fixed proportion for future R&D and short-term product development. Rather, projects in both categories are reviewed together several times a year, and management decides on each in the full context of the company portfolio.

SAES Getters is also impressive for the 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.

Many of the firms also used a formal portfolio analysis process to balance risk across radical and incremental projects, balance investments across incremental to long-term and radical (blue, gray and white space) product ideas. The goal was to enable a steady flow of projects and revenue and to provide business units with steady streams of new technologies to meet their future business goals. Though few companies we visited had many investments in pure white space concepts, technology managers mentioned they used either bubble diagrams (risk/reward) or Monte Carlo simulation to measure the value of new project ideas and to balance their portfolios.

So too, all the firms appeared to be well aware of the value of intellectual property (IP) and the danger of rejecting ideas too soon. Merck, in the intellectual-property-intensive pharmaceutical industry, was particularly attentive to this. Ideas that were rejected for development were archived and revisited during succeeding project selection cycles to determine if the ideas now had additional merit.

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 throughout the organization and used in strategic decision processes. Second, portfolio analysis and stages-and-gates methods are being widely accepted as the tools of choice for selecting and tracking R&D projects. These tools add structure for driving strategic vision into bottom-line results.

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

ASML

ASML's business strategy is to produce the world's best wafer steppers by focusing resources on their core competencies, which are core design, an extensive and (in our view) world-class collaborative innovation network, and supply chain management. No significant component manufacturing is performed in the company, only assembly. Design of parts is done collaboratively at a conceptual level first and then ASML works closely with suppliers to implement detailed design, manufacturing, quality control and delivery.

Regarding our question about the corporate response to the significant worldwide slump in technology industries, ASML's experience was particularly instructive. The semiconductor equipment industry is notoriously cyclical, so dealing with strong business cycles is a critical strategic skill. ASML focuses on customer satisfaction, technological expertise, operational excellence and top financial performance in order to gain market share with downturns in the economy. How? By investing in leading edge technologies during the downturns to be able to take advantage when the upturn occurs.

The strategy has been remarkably successful. The firm has 54% market share today, up from 30% in 2001. With powerhouses Canon and Nikon as key competitors, ASML believe they are able to gain share in a down market because of superior designs.

In another strategy for growth during downturns, though ASML's business model relies on selling hardware related to their imaging systems, they are looking closely at the service business of their installed base as a new source of growth. Lenses, wafer handlers and other key components in their steppers are modular allowing them to more easily change designs or even suppliers. This modularity is also a competitive advantage over Canon and Nikon. In addition, volatility in the semiconductor manufacturing market is directly correlated to the number of required workers in the industry. However, in ASML's case their workforce does not need to fluctuate nearly as much since they are a single, yet critical link in the supply chain. Most of their suppliers are absorbing cutbacks in the industry.

CERN

The competitive/business strategy of CERN is clear: CERN's existence is the result of several European governments' desire to develop a world-class collaborative research facility to advance understanding of our universe with an emphasis on particle physics. CERN exists entirely for R&D. Fundamental and applied research is its only focus.

Managers believe that alignment between R&D and strategy is accomplished through clear definition and communication of objectives. A

common understanding of objectives is the most powerful leadership mechanism they have: "establish clear objectives, and the program will almost lead itself. Managers simply keep the program aimed at these objectives."

CERN does not look for "business opportunities." Rather, they strive to find solutions to basic research problems facing researchers across different geographic locations and across several industry boundaries. CERN has a rich source of information relative to leading edge research in this area since their staff is comprised of leading researchers from around the world.

CERN is in a unique position because they are somewhat isolated from the cyclical vicissitudes of technology industries. The strategy and objectives of CERN are typically unaffected by the winds of change in the technology sector, although they are not completely immune to global economic downturns. CERN funds are affected by recessions mainly through the significant impact on government spending.

On the topic of disruptive technologies, as the many Nobel prizes that have come from CERN researchers will attest, CERN's activities are responsible for many fundamental breakthroughs that eventually lead to new technologies and solutions (e.g. materials science, medical imaging, computing).

DaimlerChrysler

DaimlerChrysler has what we found to be an enviable method for building strategies for the future, a long-term strategic vision called Scenario 2020. This scenario paints a picture of social and technological life 17 years from now and how their key market segments fit into that everyday life. This strategic vision has four elements, which collectively shape R&D activities, and is detailed enough to give people a tangible framework for decision making. The four key elements the Board of Directors believe are: 1) sound economic growth, stable income and limited inflation throughout Europe and most of the world; 2) ever increasing environmental regulations; 3) worldwide overcapacity in the automobile industry, with challenging competition; and 4) a need to excel in all competitive disciplines.

Driving forces of this scenario are, broadly, social and regulatory. Social driving forces include the sustained need for mobility in the developed countries, a growing desire for mobility in developing countries, an increasing sensitivity to environmental issues, and a shifting orientation from wealth and status to health and excitement. Regulatory driving forces include the tightening of laws governing fuel consumption and emissions, increasing safety standards, and greater consumer protection.

The strategic vision is reviewed at every Board review, about every 6 months, to ensure continuing appropriateness. Significant attention is then given to making sure the resulting strategic vision is made visible to and understood by everyone in the R&D organization. Each manager cascades objectives and tactics down. The primary management challenge is managing the interfaces between the various corporate branches to keep them all aligned.

By contrast, the topic of radical innovation did not seem to be of special interest at DaimlerChrysler. Our assessment from this visit is that management of technology and innovation at DaimlerChrysler is largely an incremental activity. DaimlerChrysler is in the land transportation business. They have had forays into other forms of transportation, and still do to some level, but their core strategy targets cars and trucks. Business units leverage existing technology from the research centers and try to maintain strong relationships between business unit managers and the lab managers (centers of competence) and project managers (who develop the technology for commercial use) to grow the overall business.

Eurescom

As a cooperative R&D management services organization, strategic direction at Eurescom comes from a joint decision-making process among its shareholders. 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.

Moreover, there is no core R&D done directly at EURESCOM. The organization has competencies in program management for service providers engaged in wireline and wireless operations. However, given the dramatic downturn in telecom, it appeared to us that

EURESCOM is looking to expand its share by attracting European suppliers and vendors of telecom companies, as well as to provide program management services for non-European network operators. Eurescom also contracts with the EU on a project-by-project basis.

The research activities that Eurescom coordinates 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.

Merck

Merck's strategy is to rapidly deliver market-leading products, carefully targeted by intimate market knowledge, to meet customer needs. Low cost production is not a priority, especially if it interferes with the goals of product leadership and customer intimacy.

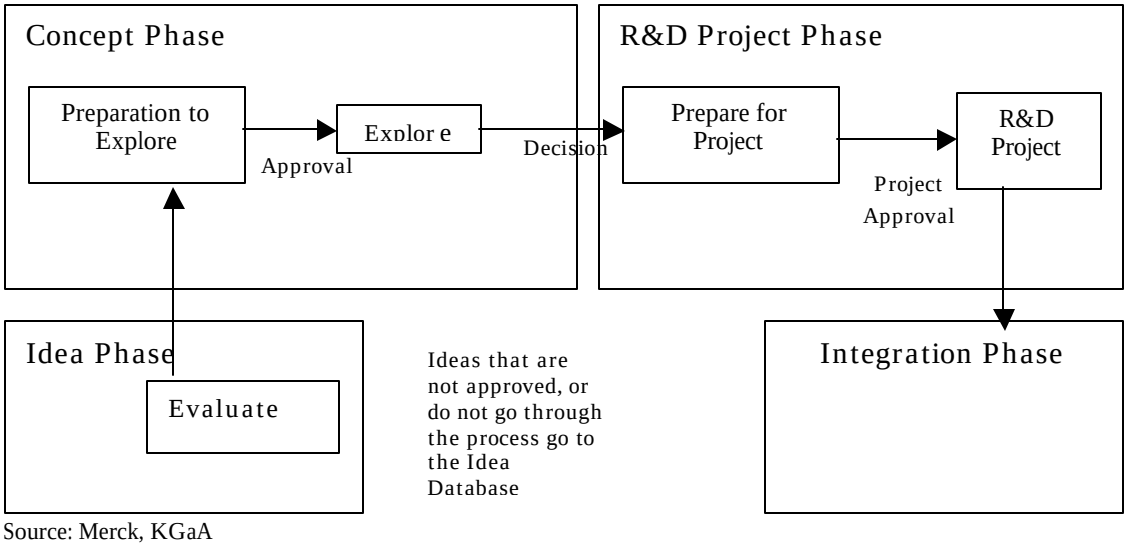
Merck uses a project-stages and decision-gates process to align technological innovation with business strategy. In their view, innovation is "the successful exploitation of new ideas and is a vital ingredient to competitiveness, productivity and social gain." They see innovation holistically, as equal to invention plus translation into practice plus commercialization, and decision-making gates exist between the various phases of this invention to commercialization process. The early gates effectively screen out ideas that do not align with the competitive/business strategy.

In making decisions at the various gates, specific evaluation criteria used include the following:

- Attractiveness
  - Technology potential
  - Degree of innovation
  - Protection against imitation
  - Fit to Merck strategy
  - Fit to business strategy
  - Market opportunity
- Probability of Technical Success
  - Existing competency
  - Technology maturity
  - Complexity
- Probability of Commercial Success
  - Customer benefit
  - Competition
  - Access to market
  - Public acceptance
- Financial Reward
  - Net present value (NPV) – expected profitability
  - Financial return
  - Payback period
  - Certainty of return

Merck's conceptualization of this stage/gate process is shown in the schematic below.

The uncertainty inherent in market analysis remains Merck's number one problem area for evaluating new ideas. Technology forecasting, societal factors and market pull all help in estimating potential markets. R&D has developed a strong relationship with marketing to better evaluate new ideas. Data mining of patent information and other literature is also used to monitor industry directions. Despite these tools,



Source: Merck, KGaA

Merck market estimates remain uncertain.

A portfolio analysis is completed every 6 months to review the mix of R&D activities and to score new ideas. Merck has what they call an R&D idea portfolio that includes a bubble map showing the "Success Probability" against the "Attractiveness." The size of the bubble indicates financial reward (typically NPV). A portfolio approach is used to pick a mix of investments to balance risk. The portfolio is shifting toward more "blockbusters" or radical innovation projects targeted at low volume/high margin products.

Innovation time is 10-15 years for their products and has been that way for many years. Complexity of the product line is increasing. Since the increased complexity should increase the time, they believe the stability of the 10-15 year timelines actually indicates improving performance.

The strategic planning process seems to us to work well, driven by a clear vision of where the company is headed. Having the Merck family own 74% of the company allows management to maintain a long-term focus rather than worrying so much about target quarterly earnings. There are challenges to overcome, however. The decision-making process apparently remains slow and is seen as a singular event rather than a continuous process. Moreover, a stronger customer focus needs to be injected into the culture. Reduced bureaucracy might help. Younger employees are less and less likely to put up with barriers from hierarchy, bosses, etc. In our experience, many young technical people enjoy the challenge of being entrepreneurial.

MEDEA+

MEDEA+ gets strategic direction from its member companies, where the project ideas originate. The hierarchal committee structure that is used to govern the organization encourages broad input from partner companies, from member countries and from the Scientific Committee, which scans worldwide for technology developments of interest. The broad input combined with the committee structure results in projects of broad interest to the members and effectively keeps technological innovation aligned with overall strategy.

MEDIA+ uses the following decision making structure:

- MEDEA+ Board – provides strategy and coherence for entire program
- MEDEA+ Support Group – evaluates projects and handles operational issues
- MEDEA+ Scientific Committee – tracks worldwide progress in areas of interest
- MEDEA+ Steering Groups – recommends, initiates and monitors projects
- MEDEA+ Office – central contact point for all of MEDEA+

Philips Research

Funding and project selection at Philips Research are driven by a percentage split between the product divisions and more long-term research. About two-thirds of research activities involve contracts with the product divisions. These are negotiated on an annual basis using a fixed cost per researcher. The other third is funded at the central corporate level, and Philips Research management determines the projects. The total budget for Philips Research is roughly 1% of total sales and represents slightly more than 10% of the total R&D activity in Philips.

Philips is driving toward managing R&D by strategic direction. As stated in their presentation slide set: "A continuous process of improvements from 'doing the things right' towards 'doing the right things'. "

Philips Research is structured as a series of inter-related technology silos. Some research activities, such as in Healthcare systems, directly target specific customers and product areas. Other silos, such as Devices and Micro-systems, encompass broadly applicable technology components that support across the other silos horizontally. This "Program Haystack" allows Philips to view different R&D investments and make decisions across and among the different silos.

For the corporate-funded projects, Philips uses a set of Long-Range Technical Objectives (LRTOs), which are created by a team of research experts, to guide the portfolio of activities. As a unified set, the LRTOs become the long-term strategic R&D vision, and programs are presented to show and track progress towards that vision.

Part of this activity entails a closer relationship with the customer base, rather than using the business units as a buffer. Philips Research has begun inviting customers to what

had for many years previously been entirely internal lab show-and-tell days. At these days, both internal and (now) external research clients are able to learn (and perhaps influence) what technologies are being researched. This has led to a better relationship for all three: customers, business units and central research. The Director mentioned some level of nervousness at first with questions of sharing secrets. However, he believes that Philips has lost more opportunities by doing research behind closed doors without customer feedback than they have from spies. Several members of our student team liked this show-day concept as a potentially valuable innovation to implement in our own organizations.

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. The company's organizational structure is constantly monitored and modified so that it is in line with current effectiveness to the business.

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. The communication with customers is facilitated through both the marketing department as well as engineers to ensure that customer needs are incorporated into the product.

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, with changes that will be 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.

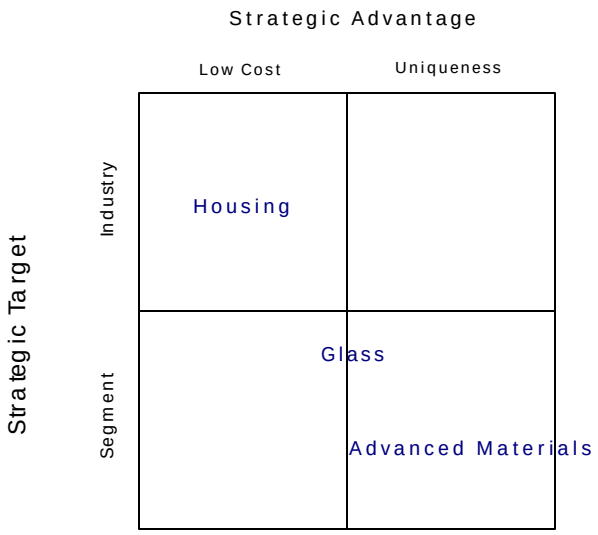
One of the core ingredients that SAES uses to maintain a well-balanced strategy is to keep employees focused on new technology in addition to the current incremental work planned for the year. For example, most if not all employees know what the five to ten year strategic company goals were. In addition, the company works at ensuring that each employee understands the company's long-term research direction, which facilitates a broad and clear understanding of the research mission and the continued renewal of the intellectual property pipeline. The idea is in part to develop new products not only by looking at the needs of the customer today, but also by looking at possible future incremental and radical technologies as they relate to the where customer needs might be five to ten years from now.

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) process innovation and product design in the central Technology and Innovation Laboratory; and 3) manufacturing. The scientific work may result in formal papers to the scientific community, depending upon their intellectual property 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.

Saint-Gobain

The following figure shows how Saint-Gobain conceives of their business/technology strategies in their various business segments:



source: Saint-Gobain

Saint-Gobain utilizes a communication process of "cascading objectives" to align managers and employees at all levels of the company relative to business objectives and competitive strategies. Each of Saint-Gobain's many Research Centers is aligned with one of its business groups (flat glass, glass containers, glass reinforcement, glass insulation, plastics/ceramics, abrasives, piping, building material, and distribution). The additional 60 or so smaller development units are closely tied to a business group as well. The groups fund about 75% 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% of R&D funding, although supplied by the branches, is allocated to projects based upon Corporate R&D decisions. The President 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% 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.

Saint-Gobain is very sensitive to radical and disruptive innovations since several of their businesses are high risk relative to substitute technologies and/or fierce competition. Therefore, their processes for technology monitoring and forecasting are not only critical for identifying new business opportunities, they are also important for protecting and guiding their existing core businesses.

So, Saint-Gobain actively monitors emerging technologies and trends in their core business segments by collaborating with Universities on research programs, membership/participation on standards bodies, and participation in technology and trade conferences in areas related to their core businesses. They also have several internal monitoring and screening processes for evaluating emerging technology trends, and information from these evaluations is fed directly into their selection process for research and new product development projects. Saint-Gobain also uses several empirical R&D metrics to track the "usefulness" of their research programs relative to meeting customer needs, which is an indicator of whether or not they are accurately identifying business opportunities. Managers at Saint-Gobain believe they are effective at incorporating

information on customer needs into their selection process for research and new product development. They also believe that this process for evaluating research effectiveness relative to customer needs gives them a competitive advantage.

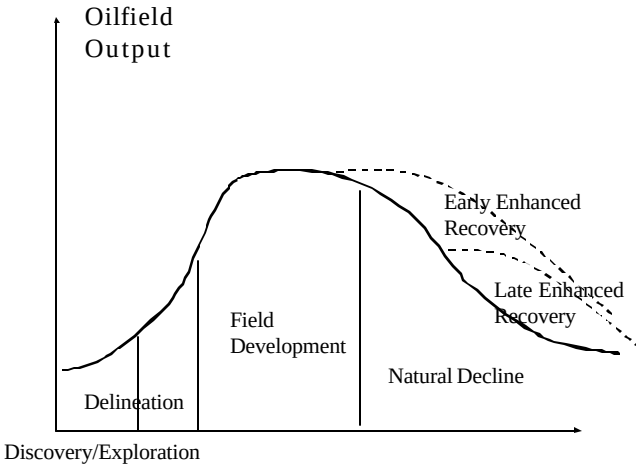
Saint-Gobain also promotes the development of radical innovation through patent incentives and employee recognition for breakthrough results in research and new product development. They have also become proficient at 'make-team-buy' evaluations, which enables them to react quickly to new opportunities and/or defend current businesses via internal development, technology acquisition or collaborating externally.

Saint-Gobain's core businesses are 'low-tech', commodity markets, so they have been somewhat buffered from the slump in technology industries. The depressed economy does place additional cost pressure on their commodity glass and housing materials products since they need to maintain margins and cash flows to support their high-performance materials business. The high-performance materials business has been resilient against the slump in tech segments.

Schlumberger

Schlumberger is fundamentally a measurement company, addressing questions such as: Where is the oil? How much is there? What is its quality and how much will it cost to extract? How long will the oil field produce? They sell the results of their work to oil companies. In addition, a significant fraction of Schlumberger's innovation activities focus on oil well enhanced recovery techniques.

The diagram below illustrates the lifecycle of a typical oilfield.



Strategically, Schlumberger management sees early and late recovery techniques as major growth opportunities. This is because the cost to set-up and tear down an oilfield make it practical to invest in technologies to keep the field producing as long as possible. In 1999, just 10% of Schlumberger's oilfield-services-segment revenues were from this area. Schlumberger now expects 20% of its oilfield services revenues to come from these new technologies.

Schlumberger management understands that failure is important to their innovative and commercial success. A 100% success rate would mean their people are not taking enough risks. Management allows for some skunk-work projects, for those employees who want pursue independent visions on a limited basis. The policy appeared to be geared to inspire innovation as much through culture and environment as through specific focus on stated corporate objectives.

Such a visionary leaning in the innovative environment is valued because disruptive technologies are important to Schlumberger's efforts to maintain competitive advantage. One innovation technique they have found effective is to hold an offsite ideation retreat every year. These retreats are one part of a set of formalized processes to stimulate ideas around key technology areas. Over the two-day retreat, participants are given five generic themes from which new ideas are captured. The whole process sounded to our study mission team to be effective in stimulating new business ides. The session in 2002 produced 57 new ideas that were seriously pursued. Schlumberger also uses a formalized suggestion box approach though not much information was available here. Rejected ideas are never thrown out. Rather, they are reviewed at the next ideation session.

STMicroelectronics

We were impressed with the processes by which STMicroelectronics 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. As described to us, Global R&D, including multiple advanced R&D laboratories and dozens of design and application centers, seemed well aligned with the corporation's

objectives. These objectives included market leadership in flash memories and system-on-a-chip (SoC) devices, which integrate disparate functions onto a single device. ST management believes they have a competitive advantage in SoC because of the breadth of their product leadership, which extends across non-volatile memories, logic and power circuits.

R&D is organized at different levels in the company. About half of the total R&D budget is tagged for "Corporate R&D," which is further subdivided into exploratory and evolutive. The former receives one-tenth of the corporate R&D budget and is focused on looking for new breakthrough products/technologies. Evolutive R&D is focused on advanced system technology and is more incremental. The other half of the R&D budget is split between product group R&D (product family specific innovation) and division R&D (IP's, design). Here, ST focuses on intensive product development, especially in close concert with key long-term strategic allies such as Nokia, Seagate Technology and Alcatel.

Central R&D manages development of semiconductor process technologies. Moore's law and the continued increase of factory costs are two fundamental assumptions guiding ST strategic decisions. Although some technology development is market driven and pulled into products by particular technology 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. When designing new products, integrated pilot lines improve time to market, time to high volume, faster process transfer, cost optimization and manufacturing methodology.

ST has a strong patent portfolio. Intellectual property came up often during our discussions with senior managers and seemed to be of high importance, though they did not say if they use patents mostly for cross licensing, limiting the competition, or differentiating their own products.

The firm has also won many awards for its commitments to manufacturing quality, environmental responsibility and employee satisfaction. Its top-flight management has been credited with helping the firm avoid the dismal losses and big layoffs experienced by many chipmakers during the brutal technology sector downturn.

Telecom Italia Labs

Telecom Italia Lab (TIL) is focused on providing unique value to its "customers," who are not consumers directly, but rather the operating units of the Telecom Italia group: Telecom Italia, Telecom Italia Mobile and Pirelli Tires. According to the Director, TIL's vision is that there should be no one else in Italy who can provide the same value to these customers.

Yet, in general, the Telecom Italia Lab seemed to struggle with providing clear value. This partially stemmed from the difficulties in research and development related to services. One statement from the lab Director indicated that it was difficult to prove R&D value especially for a telecom operator. To paraphrase, we believe what he meant was: "What is the meaning of R&D in a service center?"

We were shown a two-pronged strategy. The first prong was enhancement in specific technology areas: e.g. voice services via the internet; advanced digital subscriber line (ASDL) access; high performance fiber optic networks; digital security; wireless services. The second prong of the strategy was seeking ways to increase the demand for network bandwidth. This latter was the goal of the research in the Broadband Home Laboratory, one of the demonstrations for our team during our visit. The lab brainstorms and prototypes new ways in which the home user could use high transmission rate capabilities.

At one level, the members of our Study Mission team seemed unimpressed with the specific technologies demonstrated to us in the Broadband Home Lab, since each individual element was already commercially available in the States (TiVo for example). Yet, from a more strategic perspective, we appreciated the lab in its holistic attempt to bring together a wide and disparate range of emerging existing home technologies and to envision how they would come together to drive demand for more broadband access.

TIL's criteria for investing in projects are based on specific direction from the Telecom Italia group. Sixty-five percent of the lab's activities are directly related to requests from the group's business units, split about 50/50 between Telecom Italia (the wireline business) and Telecom Italia Mobile. Another 25% is longer term in outlook and funded centrally at the corporate level. At TIL, such "long term" activities, including the Broadband Home lab, are about 18-30 months from the actual revenue generating stage. Specific longer-term activities are proposed by TIL and either accepted or rejected by corporate management. For approval, these activities require a business plan and financial analysis (e.g. net present value, internal rate of return). The final 10% of the overall lab activities are exploratory "blue sky" research projects, funded at the corporate level but with no specific corporate approval necessary.

It is interesting to note that the budget for TIL is only about 1% of revenue for the overall group, and TIL is the ONLY research and development within the Telecom Italia group. This R&D to revenue ratio seems low by product or manufacturing standards in the industries our study mission team represent, but may be more in line with service organizations.

TNO

The business-related strategic mission of TNO's research is to solve practical problems through creating a bridge between fundamental research and practical applications. In February 1998, TNO launched their strategic plan 1999–2002. It identified 14 core areas in which to concentrate R&D efforts and expertise: product development and new production techniques; new materials; information and communication technology; applied physics; chemistry; energy; building and construction; defense; health care; transport and logistics; agriculture and food; innovation management; and public safety.

This struck us as a remarkably broad range for a "core." Our firms tend to look for strong synergies between core areas, and it was hard for us to imagine that strong level of synergy across all 14 of these broadly different areas. We wondered if perhaps the use of the term "core" for this public-sector supported organization--with ties to a nationwide range of university research groups--was conceptually different that what our commercial firms think of as a core. Indeed, because of its bridging mission, TNO works closely with most Dutch Universities and technological institutes. This collaboration has resulted in 30 currently operating joint ventures, known as Knowledge Centers, where the main strategy is the knowledge sharing that comes from being close to the universities. Indeed, 50 TNO professionals are part-time professors.

TNO's current patent portfolio consists of more than 500 patents and 2000 patents-pending based on more than 250 inventions covering a wide range of applied scientific research. TNO attaches significant value to protecting the inventions developed in the course of its knowledge activities. The revenue from patents and licenses totaled €3.6 million in 2001. This revenue in turn helps fund TNO's efforts to build their expertise in the core fields and invest in its future: in new competencies, employee development, customer satisfaction programs, and new knowledge areas, as well as collaborations and alliances.

Total

Total's R&D efforts would be classified as incremental, not radical. The majority of Total's R&D budget is spent in the chemical arena (€500M) with a focus is on petrochemicals, polymers and resins. This compares to €75M in refining technologies and €85M in oil exploration and oil production technologies. These R&D dollars are managed at the corporate level. Total believes that their production technologies are a differentiating factor. One reason for attention to oil production technologies is that many of their production facilities are off-shore, due to Total's relatively late entry into the business. Other current focus areas include renewable energy, analytical sciences, process engineering and catalysts (for refining).

Unilever

Unilever competes in a wide variety of markets and countries on brand identity, with brands and products tailored to specific countries/markets. Unilever spends heavily on advertising, as brand identification is essential for marketplace success. For developing overall corporate strategy, Unilever employs an ongoing Porter-five-forces analysis. Unilever's recent strategy has been to focus both R&D and marketing on fewer leading brands, i.e. those

most in demand from consumers. Executives made a strategic decision to cut brands from 1600 to 400 in the last few years.

R&D activities involve a staff of 8000 people, and a €1.2B budget. Unilever focuses on targeting its brands at consumers' specific needs and spends a significant fraction of R&D on market research in order to anticipate consumer demands and optimize mass customization. Innovation is especially important in personal/home care to maintain strong market position. Main technical areas encompass life sciences, material science, consumer understanding, nanotechnologies, process technologies, physics and chemistry in food and the home, and information and commercial technologies (e.g. SlimFast and the Internet).

The R&D activities are organized into research centers: Food, New Products, Corporate, and Global Technology and Innovation Centers. The Food Research Center, for example, targets R&D in the life sciences with applications in flavors and consumer perception. Because historically there has been a roughly 90% failure rate for new food products, Unilever is looking for ways to improve their understanding of things like the psychological corollaries to people's response to taste, since many auxiliary effects influence how people respond to food. Because of the worldwide breadth of their sales, research also includes issues of supply chain and distribution systems.

We particularly enjoyed our discussion with Unilever R&D executives about the evolution of their management philosophy, which they characterized using the timeline illustrated below.

In the 1980s, defined products and market positioning largely drove Unilever's R&D strategy. Then in the 1990s R&D was driven more at the level of business units, which were also given more incentives and freedom to be entrepreneurial. Unilever today is driven by customer-oriented brand identity. For example, the Bertolli brand evokes Italian, healthy food, but encompasses far more than the product-level olive oil. Unilever continues to move further in this direction by taking a more holistic picture of customer desires. So too, through the Internet, Unilever now exchanges knowledge/information directly with consumers who visit product websites.

	Knowledge	Products	Business	Customer
Learning				x
Entrepreneurial			x	
Positioning		x		
Planning				
Design	x			
	1970	1980	1990	2000

Topic 2: External Technology Acquisition through Networks, Alliances & Acquisition

In the US, we find that effectively leveraging the external relationships of our technology-based firm requires a close integration with competitive/business strategy.

- Given the potential costs involved, entering external relationships requires a compelling business case. Why do you seek the competencies externally rather than developing them internally?
- How do you select the firms you partner with?
- 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, responsibilities, accountability, resolving conflicts and ensuring effective communication?
- How do you measure the performance and effects of these external relationships?
- Do you have external relationships that work particularly well? What factors make the more successful relationships work, when compared with less successful ones?
- How do you manage and protect intellectual property in these relationships?
- How do you cooperate with competitors in such alliances/networks?

Topic 2: Summary & 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 DaimlerChrysler, Fiat 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.

ASML in particular stood out for its effective strategic use of networking. 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, ultra-high precision mechanics and materials. STMicroelectronics' 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. MEDEA+ stood out for its ability to facilitate collaboration between many different companies with a very small staff

In general, firms were most concerned about dealing with competitors. How to deal with intellectual property was an ongoing theme in collaboration. Nevertheless, similar to our US companies, the guiding principle was clearly cooperation to enlarge the market, then to compete for a bigger piece of it. This was particularly true in standardization and longer-term research efforts. Our visits to the cooperative research organizations MEDEA+ and Eurescom were prime illustrations. Both involve significant cooperation and joint funding of longer-range research projects among competitors: among European telecommunication within Eurescom and the European semiconductor industry for MEDEA+. Indeed, Eurescom might be an example of a purely networked organization, as its principal function is to 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. MEDEA+ has a very "lightweight" structure

that allows easy partnership with minimal overhead. It has positioned itself as the government expert for choosing projects, which seems to be a long-term recipe for success.

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 and other Asian universities were under-represented. Total was the exception to this with their technology scanning efforts centered in Japan.

Acquisitions are also an important mechanism for access to both technical expertise and markets, although several firms mentioned significant difficulties in integrating diverse cultures. STMicroelectronics has a particularly impressive acquisition and integration process, which was especially interesting because of its success in developing a coherent corporate culture despite a continuing series of acquisitions.

The following excerpts from the participants' notes on some site visits reflect additional reactions to Topic 2.

ASML

Acquisition has been particularly important for ASML, which in 2001 acquired US-based SVG, a major producer of lithography equipment, as a result becoming the world's #1 lithography equipment firm.

So too, as mentioned above, our group considers ASML a best-in-class example of leveraging external R&D collaboration for competitive success. To identity emerging technology and business opportunities, ASML collaborates with IMEC in Belgium and STMicroelectronics in Crolles, France to work on new prototype systems. ASML deals with 300+ suppliers, and uses multiple alternative suppliers to manage most of its higher risk technologies. The only exceptions are lenses (Carl Zeiss) and lasers where these critical technologies are sole-sourced. ASML also has regularly participated in consortiums in Europe and internationally (e.g., leading the 157 nm Consortium and participating in the US-led Extreme Ultraviolet consortium, EUV). In an information sharing mechanism we found interesting, ASML relies heavily on its website for document sharing to help facilitate the link between customer needs and supplier specifications.

Moving on to the issue of intellectual property rights, IPR is negotiated before engagement with suppliers. New intellectual property developed in collaboration with suppliers or partners tends to be owned by ASML since they are the ones paying for the engagement. Intellectual property protection is also part of the contract with employees, although we got the impression that people moving away from ASML is not as significant an issue as in some of our own industries due to limited direct competitors.

CERN

Collaboration is a fundamental imperative of the CERN concept. The underlying premise of CERN is that member states and participating researchers can pool their funds and resources to take on projects that would otherwise be too large and costly for any single state. Therefore, international collaboration and reliance on external competencies are the fibers that bind CERN. Indeed, CERN is credited with inventing the World Wide Web, because a CERN scientist Tim Berners-Lee invented the WWW concept (that combined HTML coding, HTTP protocols, web browsers, and a software-platform-independent consistent user interface) in order to facilitate collaboration and large-data-volume information sharing among high-energy physicists.

CERN's selection of partners is a function of the projects and programs under consideration. CERN strives to collaborate with leaders in industry/academia who have demonstrated either a clear competency advantage or those who are working in an area that is aligned with the research at CERN. In most cases, CERN does not seek particular industry or academic organizations as much as they look for particular individuals with expertise in an area of interest to CERN. Given its focus on research problems at the forefront of particle physics, CERN typically works with the world's top scientists and researchers, who are generally straightforward to find.

CERN managers work closely with partners to establish and communicate program objectives that are aligned with their overall objectives and

research directions. They feel that establishing common objectives is critical to keeping large-scale projects on track since it gives the large network of collaboration a common reference of focus for the program. They also believe this is a powerful vehicle for resolving conflicts since misalignment of fundamental goals and objectives is typically the root of most conflicts. After common goals are established, CERN managers follow a thorough process of defining and assigning roles and responsibilities across all partners. They also complete detailed cost evaluations and outline budgetary requirements while completing short-, mid- and long-term schedules, resource plans and communication models for the program. CERN managers believe that accountability is controlled by assigning ownership, so they work with all partners to ensure that each owns significant pieces of the program, with clearly defined deliverables and schedules. They believe giving each partner "skin in the game" maximizes accountability. CERN managers and researchers are also good at establishing clear and open lines of communication for their programs. In addition to understanding the management processes required to keep a large collaborative network in sync, they have also been innovative in how they utilize technology to maximize effectiveness of communications. CERN continues to extend the Internet as we know it to further improve communication and data management capabilities with a research program towards what they are calling "The Grid".

Research performance is measured by completeness and timeliness of deliverables. This is tracked closely since historical performance of individuals and partner organizations is a significant factor of future project and partner selection.

All work at CERN is published, so intellectual property issues are resolved before starting any research project. In nearly all cases, CERN works with partners to establish a joint development agreement that allows partners to utilize results for their own purposes. They also establish agreements to protect existing intellectual property of their partners. These agreements also protect partners who develop proprietary solutions and technologies that are not direct results of the research (i.e. supporting technologies that are not a direct result of the CERN research or associated deliverables).

DaimlerChrysler

DaimlerChrysler has no explicit collaboration strategy. They do have a policy within each business unit for deciding "make/team/buy"--i.e. whether to internally develop, to partner or to acquire. These decisions are made on a case-by-case basis and are controlled by several driving forces: customer expectations, regulatory requirements, competitive pressures, resource restrictions and technology considerations. In our experience as technology managers in US firms, these are the same types of decision points driving most technology companies.

Eurescom

Eurescom exists essentially to coordinate and manage external collaborative efforts of its shareholder companies. Intellectual property agreements signed before projects begin define foreground and background information, what each participant owns beforehand and what will be shared. There are two levels of sharing. Roughly 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, with the property rights to that information shared only among the firms participating on the particular project. These are sometimes available to those shareholders not participating directly in the project, but only after a lag. Eurescom's role is to help the participating firms take the technology as close to product status as possible before the partners take the final commercialization step. Although intellectual property is shared only with the participating firms, Eurescom management believes that "access to the rights is not the same as understanding the technology."

However, it appears that participating firms have had a tendency to hoard intellectual property in order to gain a competitive advantage. According to Eurescom's Director, there is today much more technology available for use than what has been commercialized. He believes there is too much focus on competition and bottom line (dividing the pie) rather than innovation and growth of the overall market (expanding the pie). Among the 15 shareholder companies, only 2%

of their R&D budgets is spent on collaborative activities. The remainder is internal to the firms. The tension between efforts to divide and to expand the market is even greater now following the recent technology sector bubble. There is significant debt among the many Eurescom shareholders who are telecommunication service providers. Debt from over-expansion and from payments for Universal Mobile Telephone Service (UMTS) licenses are weighing the industry down and preventing research on new services.

Fiat Research Labs

Fiat hinted that they use a formal model for strategic value chain analysis when assessing strategic plans and directing external relationships. Fiat R&D executives believe strong external relationships can create an organizational capability for fast response to dynamic markets and technological change.

Fiat utilizes technology scouting as a formal process to capture external roadmaps and identify technologies critical to Fiat's future. FIAT proactively identifies what competencies will be needed to exploit the early phase of the s-curve for emerging technologies and collaborates with universities to get the right skills. External technology scanning also appeared to have a large supplier identification component for each of the 12 sectors in the company.

In addition to working to absorb technologies from external sources, Centro Ricerche Fiat (CRF) has been committed to transferring technology internally throughout Fiat and externally to customers in both automotive and non-automotive sectors. Fiat has also created 26 specialist clubs within the company to foster linkages to internal and external technologies. The goal of the clubs is to accelerate technological growth and competitiveness of it internal participants.

Fiat has particularly strong internal capabilities in diesel technology due to their success in European diesel vehicles markets. Fiat is collaborating with General Motors in diesel research for application in GM's diesel commercial vehicles. Another significant emphasis of Fiat's recent collaboration with competitors has been in establishing industry standards. An example would be a major alliance with GM in 2000 that proved to be a powerful stimulus for the development of common architecture and components.

MEDEA+

MEDEA+ involves significant cooperation and joint funding of longer-range research projects among competing semiconductor firms. Indeed, its principal function is to help coordinate and direct distributed R&D projects among cooperating firms. The ownership and use of intellectual property developed in a MEDEA+ project is well defined and agreed upon before the start of the project. MEDEA+ has an admirable very "lightweight" structure that allows easy partnership with minimal overhead.

Merck

Merck actively works to collaborate with universities and participate in consortia, although proprietary intellectual property is still paramount. Both chemical and pharmaceutical patents are quite valuable because molecular structure is fixed, making it difficult to design around a patent in these industries. Cooperation with competitors is done on a pre-competitive basis (e.g. to answer questions like: Is the chemical in question toxic?). There is limited access or exchange of intellectual property. Thirty percent of Merck's R&D budget is spent in collaborative programs. Merck also relies on partnerships with companies in their value chain to minimize risk.

Philips Research

There was limited discussion of the topic of networks, alliances and acquisitions during our visit at Philips Research. During the human resources discussion, there was mention of developing relationships with specific universities, but this was framed as a way of identifying and recruiting top talent.

The Director did mention the need for partnerships in high cost industries, semiconductors specifically. The scale of innovation and capital investment required almost forces partnerships, especially for those companies competing with the likes of Intel. Philips, STMicroelectronics and Motorola have a partnership for semiconductor development. Competition becomes fierce once the research reaches the application stage, but the partnership is necessary to get to that point. Indeed, we also note that Philips has been working closely for many years with the European Commission in

helping define EU technology policies, particularly with respect to collaborative R&D programs in semiconductors and information technologies.

SAES Getters

When asked about what makes SAES Getters successful, it has been said that a large part of their success is due to their R&D collaborative efforts with outside organizations, including universities as well as their close collaborative efforts with customers. SAES has alliances with large customers/partners to create end-use products and a need for SAES' components. The reasoning behind developing good collaboration with outside companies is to ensure good product integration for the final market deliverable. Without these partnerships, its component business (getters) would be limited. Therefore, collaborative partnerships 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. Even though 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 common practice. These businesses were in similar fields and SAES Getters bought them to build upon existing business. For example, SAES acquired a gas-purification equipment company located in California, which also allowed managers to hire qualified people from that high-tech labor pool and to assume a manufacturing site.

Saint-Gobain

Saint-Gobain has developed a rigorous evaluation process ("make-team-buy") for decisions on the best way to incorporate new technologies into core businesses. When deciding whether to develop internally, partner externally, or pursue an acquisition to get the technologies needed to remain competitive, Saint-Gobain assesses several key parameters: time-to-market, cost, strategic alignment, and competitive significance of the technology. To date, R&D executives believe this process has proven quite effective, resulting in a good balance between internal technology development, partnerships and acquisitions.

Saint-Gobain actively monitors emerging technologies and trends in their core business segments by collaborating with Universities on research programs, membership/participation on standards bodies, and participation in technology and trade conferences in areas related to their core businesses. A tougher problem is deciding what options to pursue. Based upon years of refining their selection process, the executives indicated that the key is doing diligence in the early stages of the selection process. In their view, most of the issues associated with efficient access to external technologies and integration of them into Saint-Gobain's core business can be resolved at the onset. They commented that they have a high success rate on acquisitions and partnerships relative to the established goals for these programs.

Performance of external relationships is measured along two fundamental vectors: 1) the timeliness and quality of all program deliverables; and 2) the perceived effectiveness to customers of the technology or solution when it is introduced to the market.

STMicroelectronics

STMicroelectronics was formed in 1987 through a merger between existing high tech companies, the Italian firm SGS Microelectronica and the French firm Thomson-CSF. This merger legacy remains noticeably fresh in their memory and they seem to us to be quite comfortable working with different companies and geographies. They have been quite active acquiring and collaborating with firms throughout the world, and in our conversations with R&D executives they spoke often about collaboration with academia. Since STMicroelectronics is Europe's primary high-tech semiconductor research firm, the firm's researchers have strong, open and largely exclusive relationships with academia.

The acquisition and cooperative alliance history struck us as remarkable, given how unified STMicroelectronics' corporate vision seemed to us to be. According to Hoover's Online, shortly after its 1987 merger, to secure market presence the firm began acquiring and forging alliances with major chip buyers such as Alcatel, Hewlett-Packard and Sony. By 1993 ST had become the world's #1 maker of erasable programmable read-only memories (EPROMs), and the company

bought Tag Semiconductors, a maker of low-cost chips, from US conglomerate Raytheon. ST opened its largest software design center outside Europe, near New Delhi, India, in 1995. The company formed development deals with Philips Electronics (for advanced chip manufacturing processes) in 1997 and with Mitsubishi (for flash memory chips) in 1998. In 1999 STMicroelectronics bought Adaptec's Peripheral Technology Solutions group, which makes chips for disk drives; Vision Group, a developer of image sensors; and Arithmos, a maker of integrated circuits for digital displays. In 2000, ST acquired the Canada-based semiconductor fabrication operations of Nortel Networks (which it later closed during the steep market downturn). In 2002 the company bought Alcatel Microelectronics from French telecom giant Alcatel.

Many companies struggle with efficiently integrating such major acquisitions, and aligning different corporate cultures, so we believe we can learn from STMicroelectronics' long experiences. We see at STMicroelectronics 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, STMicroelectronics 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, STMicroelectronics also makes sure that it has a culture mesh with any would-be mergers and, if so, manages the culture early in the relationship.

STMicroelectronics suggested to us a list of recommendations to make acquisitions/mergers go as smoothly 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.

STMicroelectronics does cooperate with competitors in technology development, for example, in IMEC and Sematech. Executives seem to share the sentiment that we heard at Eurescom: "Cooperate to expand the pie. Compete for a bigger piece." Their $1 billion R&D budget is focused on intensive product development, especially in close concert with key long-term strategic allies. STMicroelectronics is also active in numerous collaborative research projects worldwide and plays a major leadership role in Europe's advanced technology research programs such as MEDEA+.

Telecom Italia Labs

During our visit to Telecom Italia Labs, we had little direct discussion of networks and acquisitions. During our walkthrough of TIL facilities, our team was presented with a "system on a chip" activity, which was part of an alliance with STMicroelectronics. However, it seemed to us that this was more of a customer-vendor relationship than an actual alliance. According to the lab Director, TIL was sending its knowledge embedded within the chip, so it seemed clear that TIL created the particular design while ST would do the manufacturing.

The Director did mention a past alliance with France Telecom. However, the move away from state-owned monopolies has made France Telecom a competitor, so this relationship has generally dissolved. For this reason, Telecom Italia exited the Eurescom collaboration activities. TIL does not believe there is an adequate model for collaboration in the face of competition. This view was a healthy challenge to our own thinking as US-based technology managers, given the strong and growing reliance of every one of our own US-based companies on networks and alliances.

Total

In contrast to the other organizations we visited, Total's efforts in technology scanning focus on Japan. Total has developed cooperative relationships with the academic world in Japan, and has developed a network of people who assist Total's technology scanning efforts with discussion groups based in Japan.

Total has also collaborated with several companies to acquire specific technology to keep pace with environmental regulations.

Unilever

Unilever uses a wide array of mechanisms for technology access, including: acquisition, internal developments, joint development, external R&D, joint ventures, equity stakes in start-up companies, and licensing. Unilever also establishes long-term linkages to universities through a model of strategic investments and close joint participation with research experts. Examples include the Unilever-funded Unilever Centre for Molecular Science Informatics the University of Cambridge. Unilever also has strategic alliances with the Dutch TNO, through the Wageningen Centre for Food Sciences, which is developing longer-term S&T. Food science and safety research also lends itself to corporate collaboration because of common shared interests in health, nutrition and obesity. Unilever and the other Big Four food companies meet regularly several times annually to discuss these joint areas of R&D.

Unilever also regularly makes equity investments in early stage companies. Investment decisions are pursued through a formal process, and the typical maximum investment of is about €2.5 million per company. Evaluation criteria are:

- Existence of internal technology champion;
- Ability to watch wider development;
- Potential strategic use;
- Immediate tactical use;
- Synergy with licensing activity;
- Underpins research collaboration;
- Potential acquisition target;
- Shuts out competition.

We appreciated this list and thought it potentially useful in our own organizations, even though we are in completely different industries.

Topic 3: 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.

- How does your firm identify, recruit and retain scientifically and technically skilled people?
- How do you motivate, reward and promote them?
- How have you dealt with, during this technology business downturn, the tension between the needs to cut back and to retain technological skill sets?
- Do you foresee near- or long-term problems of a shortage of scientists and engineers or in retaining your company's 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 3: Summary and Conclusions

Three companies stood out with rigorous and in-depth human resource (HR) processes. One was Fiat. The set of processes they had developed for talent acquisition, competency management and people management were impressive. However, it seems that Fiat is in a difficult strategic position, and the focus on HR processes may be an attempt to compensate by over managing a particular area. The results of the HR processes do not seem to translate into an effective strategy. Philips and STMicroelectronics, on the other hand, seem to have both pretty well in line. They have an excellent toolset of processes for people management, and are well positioned for talent acquisition. These activities result in employees who are able to handle some of the high level positions created by their strategy and strategic processes. Ultimately, it seems you need to have both. An effective people process cannot get you out of a difficult strategic situation.

There was quite a spread of methods for recruiting and retaining top talent across the companies visited. CERN has the unique position of having the top scientists and researchers seek them out due to the nature of their operations, whereas DaimlerChrylser is much closer to the US corporate model of recruiting from universities. Many of the large, established firms like Philips, Merck and Saint-Gobain 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. DaimlerChrysler, on the other hand, indicated difficulty recruiting in fields in high demand throughout Germany, such as Mechanical and Electrical Engineering. As a result, they emphasized university recruiting more than most of the other firms we visited.

CERN responded to questioning about motivating employees with the statement that "we give them interesting work and make them accountable for it." This is conceptually appealing to us and seems fundamentally correct, and appears to work well as motivation at CERN. However, while potentially a solution in a pure research lab or academic environment, it initially struck some members of our team as somewhat impractical in competitive industry. However, we also heard very similar explicit philosophies at STMicroelectronics and Philips, and both highly successful in quite competitive markets. Both firms, for example encouraged graduate thesis research to be done at their locations in order to attract research talent.

We also noticed a wide variation among firms in the degree of multinationality in the workforce, with Schlumberger standing out as having an explicit strategic emphasis on a particularly mobile and internationally diverse workforce. They believe--and based on our observations during our visit we tended to agree--that this diversity has enabled them to maintain a more innovative corporate culture and environment.

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 struggled through the technology downturn, 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 US firms. As in the US, many of our host companies suggested that professional training is a good way to develop and retain technical professionals. SAES Getters sends some of its employees who exhibit management potential to training in the US. ASML, Philips, Saint-Gobain and STMicroelectronics all explained how they use "dual-ladder" development paths 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.

As managers and employees of companies who pay us, we were obviously interested in our host 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. Metrics included: 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 the ratio of R&D to sales by business.

Another technique we found 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. SAES Getters 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. STMicroelectronics deploys a creative metric, a potential-vs.-contribution matrix, which allows managers to find and invest in high-potential individuals. 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% today) enjoy greater exposure to the CEO and to key information and receive bonuses (~20%) based both on company and individual performance.

European technology firms, like those in the US, appear to work closely with universities. STMicroelectronics has extended university contacts beyond the local geography, and beyond the most basic methods of interaction. STMicroelectronics has relationships with the top ten 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 than at our firms.

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, STMicroelectronics noted difficulty in getting employees

from its region around Milan to work in France or even other regions within Italy. As labor mobility is a key focus of the EU, we are interested to see the extent to which this issue ameliorates in the future.

Finally on this topic, we note the strategic use of attractive, energetic campus-like environments at Philips and Eurescom in part to facilitate attracting and retaining the best talent from around the world. We also note that Schlumberger had almost the opposite strategy—intentionally maintaining high turnover and mobility to foster innovation and diversity at all their locations worldwide.

The following excerpts from the participants' notes on some site visits reflect additional reactions to Topic 3:

ASML

ASML looks for people who have a balance between technical skills, communication skills, personality, the personal drive and career focus to work in their discipline, and the ability to be flexible to organizational changes. ASML believes that knowledge is its core competency and its most valued asset, and that this value is embodied in its employees. Careful management of intellectual property is critical to its success 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 goal-oriented management-by-objective environments.

We got the distinct impression that ASML restructures frequently to respond to changing business conditions. Human resource investing and disinvesting is done on the "last in first out" method. To us they seemed to adhere to seniority more than do our US companies: rather than focusing so much on skills or scope of influence, those hired last are first out. This has the advantage of being clear and non-political, and the competitive success of ASML is hard to argue with. However, the rigidity of the approach also seemed to us to risk losing high quality new talent to the vicissitudes of short-term business cycles.

ASML motivates employees by aligning them with work that interests them. Those that excel technically are promoted in their position. ASML evaluates their leaders in four performance areas plus one area related to personal stability. The four performance areas considered are: 1) developing future business; 2) managing actual business; 3) developing technological leadership; 4) developing people and their performance. The personal stability dimension deals with the person's adaptability and trustworthiness. Currently, 25% of the company managers are grown from within the company. ASML has a long-term goal of raising that to 80%.

In terms of career development, ASML focuses on functional training and promotion within the individual's area of competence, not just promotion into management positions (dual ladder). They believe in developing employees through experience in their positions: that while people can learn from all kinds of training, the best way is by actually learning by doing, and maintaining ways of rewarding people with advancement within their expertise area. They also emphasize pride in what people contribute, together with good compensation and benefits. Employee bonuses were also a regular feature until recently, when all bonuses were suspended temporarily during the current tech slump.

It was also interesting to note that Dutch law does not allow companies to explicitly lay-off under-performing employees. Under-performers can be let go from the firm only through well-documented justification and a long termination process. This places an extra burden on the hiring managers to ensure they are certain about the employee's prospects to be successful in the firm.

CERN

CERN is in a unique position in attracting talent because the world's top researchers and scientists in particle physics get involved with CERN almost by default. CERN's charter as a collaborative research center is to collaborate with top universities, research institutions and government agencies on large-scale, leading edge research programs. High-energy physics research is so costly that no single institution could go it alone. Therefore, top researchers and scientists from institutions worldwide collaborate to engage in research that involves CERN. As for employee retention, CERN is also in a unique position here because they do not employ most of these researchers. CERN has a built-in mechanism for retention because of the simple fact that they work on groundbreaking, fundamental research, which is a key driver for the scientists who study

in this area. By definition, CERN will always be at the forefront of fundamental research, so the organizations that work with CERN will continue to attract and retain top researchers and scientists.

CERN collaborates with many top universities around the globe, and they have established several programs for training tomorrow's scientists and engineers. As a CERN publicity brochure says: "CERN plays an important part in advanced technical education. A comprehensive range of training schemes and fellowships attracts many talented young scientists and engineers to the Laboratory. Most go on to find careers in industry, where their experience of working in a high-tech multi-national environment is highly valued."

Given that CERN does not employ (pay) these individuals, they are dependent, to some extent, on self-motivation as the fuel for the innovation fire. CERN managers believe that the best way to motivate the world's best is to give them responsibility: innovation comes from their commitment to deliver.

DaimlerChrysler

DaimlerChrysler recruits technical professionals by staying linked to German universities. There did not appear to be much strategic linkage to other European universities or schools outside Europe. R&D executives indicated to us that mechanical and electrical engineers in Germany have been difficult to recruit because of the strong competing demand from other German companies in these sectors. Much to the delight of our Economics professor, we were reminded of his lecture on the relation between comparative advantage and sector-specific labor demand.

Eurescom

One HR issue that regularly comes up in collaborative projects that Eurescom supervises is the turnover of participating individuals as they leave, or more often move into other projects for their own companies. This flux means that good informal networks among shareholders and project supervisors must be maintained and that open communication is important. Such personal networking 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.

Fiat Research Labs

The level of experience and expertise at Fiat's central research labs (CRF) was impressive. The median age is 38. Among CRF employees, a striking 57% have graduate degrees, 31% have undergraduate degrees and only 12% are non-degreed employees. How they maintained such a high degree of human capital was of significant interest to us.

Fiat refers to HR as "competencies management." Their goal is to maximize the retention and use of human capital. Their current competencies management system was developed with other European partners as a part of European Union projects. Called COMPETE, it is a formalized system for managing human resources, process management, product planning and knowledge integration. It took Fiat 2.5 years to develop the system, which is just now being implemented within the research facility.

The company uses a unique, internally developed system to evaluate an individual's competencies and map those competencies to top jobs, which have the greatest economic benefit for Fiat and personal reward for the individual. The employee's immediate manager and up to four others evaluate the employee's performance. Each of these five has a stake in the employee's success (e.g. as team member or partner) to help improve the overall workforce's capabilities. . In contrast to many US firms, the manager does not have the final say in the employee's evaluations. Rather, the collective input from all the evaluators determines the employee's ultimate ranking.

According to our discussions with the CFO of CRF, employee mobility is a key strategy towards the CRF's goal of transferring technology in the form of both tangible and intangible assets to client organizations. Last year, CRF transferred 4.8% of its people to client organizations, had 7.2% turnover and ranked 43% of its people as "high potential" contributors.

Hewlett-Packard

The main human resources issue for this field office of HP concerned the challenge of enabling engineers and marketers to understand the marketplace in Europe. There was a strong feeling that US engineers and managers need to better understand the diversity within Europe. The diversity of customers drives the diversity of marketing and communication needs for HP's

imaging products across Europe. Moreover, the customer needs and the ways customers might use products (the use model) in the US are not the same in Europe.

MEDEA+

MEDEA+ project managers have a challenging role. Not only must they have technical, people management and administrative skills, but also they must have the ability to practice these skills across the many different companies that may be involved in a project. Leading an international team of resources from different companies requires different skills than just managing a project team within your own company. Requirements for a project manger at MEDEA include: technical competence; proven project management skills (managers must be both people and process experts here); and administrative skills, including the ability to follow through.

Merck

Merck highly values employees and says they are "the value drivers" in Merck's mission statement. Merck recently adopted the metrics laid out in the European version of Fortune magazine's top 10 places to work, and aim to achieve that top level of employee satisfaction as a benchmark. In the past, Merck's HR and hiring functions were localized, with no standardization among different locations. Now these functions are handled at the global level.

Merck HR executives showed us an instructive chart, below, of their current areas of focus. There is a strong focus on identifying and developing management. With more than 200 companies in more than 50 countries, the conglomerate Merck, they say, is a "company with 1000 bridges." The unifying glue among all the disparate parts is management processes/ functions. A program is in place to identify and develop inspiring and courageous leaders. The Merck University takes selected managers and gives them eight weeks of intensive training all over the world (two weeks in four different areas). Merck's commitment to employees is demonstrated by continued investment in programs like Merck University even in the current economic climate.

We appreciated Merck's efforts to create incentives for innovation at every level of the firm. Ideas to drive the innovation phase are broadly solicited and encouraged from throughout the company. Programs include a Merck Award for innovation and the Innovation Award for the best ideas of the year. Over 20,000 employee suggestions have been collected worldwide since 1986, and such suggestions are taken quite seriously and regularly implemented.

Philips Research

Philips had an extensive and impressive set of HR procedures and policies. The company views people management as a key process for success, rather than a sub-process of other activities.

From a talent acquisition standpoint, Philips is increasingly diverse. They have moved from 51% non-Dutch applicants in 1997 to 84% non-Dutch applicants in 2002. They use their reputation for interesting, and diversified research in order to attract talent from universities. They build on that reputation and the university relationships by having their researchers give presentations and talks, encouraging students to complete their thesis with Philips and allowing for student visits.

The high tech campus is also a plus. 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

Merck HR Focus Areas

Management Development	• Identification and development of talents • Framework for succession planning • Management and leadership development programs • Incremental and external recruiting
Compensation and benefits	• Design performance related compensation (e.g. €300,000 bonus for developing new drug to one employee) • International assignments to grow employees

Source: Merck, KGaA

people to their jobs.

Philips also focuses on talent development once employees are within the corporation. For management and leadership, they identify individuals with high potential and work with them to develop a "talent pipeline." They provide these "High Potentials" with additional training and try to benefit from early identification. High Potentials can move to "Top Potentials," "Executives" and the "Leadership Group." Philips also maintains a dual ladder for growth in technical fields. The Philips performance management process is consistent and standard across the company.

One technique for motivating talent and innovative energy within the Research division that we appreciated was the lab research open-house show-and-tell days. Researchers could present their own ideas, including pie-in-the-sky ones, to their colleagues and (beginning recently) to outside customers. Researchers were given the flexibility of spending a small fraction of their time during the year to pursue their own ideas independently, and could share them at these open houses. The expansion to inviting outside customers to these show-and-tell days, management believes, has helped expand market opportunities that in the past were missed because the attitude was more insular and secretive. Philips executives told us they thought the tradeoff against the risk of ideas leaking out was well worth it. We thought these research open houses and flexibility for independent pursuits were innovation management ideas our own firms might benefit from trying.

SAES Getters

SAES Getters has one of the few R&D labs located in Italy, and has a low turnover rate. Their key success factor for employee job satisfaction is their high level of management support for personal innovation as well as the long-term relationship between the company and the average employee. Indeed, SAES experiences less than 5% turnover annually.

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 six months of employment. This technique is fondly known as "trial by fire" and is in part intended as a motivational development and retention tool.

Saint-Gobain

Saint-Gobain's process of technical recruiting starts by building relationships with top universities across Europe. Saint-Gobain collaborates with universities on several projects, which allows them to sponsor students with fellowships and scholarships. They also have several students employed as interns on research and new product development projects.

Saint-Gobain is also dependent upon their reputation as a good employer in France to attract top talent. Because of its long-standing reputation in France (it's been there nearly 340 years), the company is visible and attractive to top talent in France. They also feel that their salary and benefits packages are as good or better than other firms in each of their geographic locations. Saint-Gobain uses competitive benchmarking to continually monitor their competitive position as an employer, making adjustments as necessary to ensure they are at or above these benchmarks. The company does not yet have a problem attracting top talent in France. It has, however, had some trouble 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

We did not discuss details of what they do to retain employees, although they said recognition was an important part of this. In addition to patent incentives, they publicly recognize innovative breakthroughs and significant employee contributions – they make sure that exceptional performance and innovation has visibility.

In terms of motivation and reward, Saint-Gobain executives mentioned that most promotions come from within. In addition to promoting top performers who show an aptitude for management, they have comprehensive training and development programs for employees to prepare them for higher-level roles within their respective organization. Manager and employee performance is also measured relative to short- and long-term objectives using a mechanism that is similar to the 'Balanced

Scorecard' approach used at some of our firms in the US.

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.

Another 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.

Schlumberger

A central feature of Schlumberger's R&D strategy is to combine people from different cultures and different disciplines and get them outside their comfort zones. They have an explicit HR policy of hiring employees from every nation of the more than 100 where Schlumberger has offices, and moving and mixing them worldwide, especially into the innovation centers. Their hiring practice is also to seek employees that are quite mobile, willing to move around internationally every few years. Our group had lunch in the employee cafeteria, and clearly the resulting workforce eating around us was as multi-cultural as any we have collectively encountered anywhere. Schlumberger managers believe this diversity is a significant competitive advantage, particularly in terms of stimulating innovation. From our perspective looking in, we tend to agree that the organization was among the more innovative we encountered.

In terms of motivating innovation performance, Schlumberger rewards employees who patent through cash awards and recognition dinners. They have also established an annual "Perform by Schlumberger" survey process by which Schlumberger customers can recognize and reward employees by voting for the year's best projects.

STMicroelectronics

STMicroelectronics was particularly strong in HR/management practices. STMicroelectronics uses a classification scheme along "Potential" and "Contribution" axes to group its population. This applies to everyone, including nonprofessionals. Managers appear to do a 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 predecessor of STMicroelectronics, had a long and productive history with Italian universities and STMicroelectronics appeared exemplary in this regard. Following that history, STMicroelectronics works with universities to become integrated with professors, who in turn provide managers with access to top-notch students. Indeed, more than 50 STMicroelectronics engineers work as professors at the universities, and so can target promising students for employment. STMicroelectronics also provides laboratory equipment and experiments to help make students aware of the company. University partnerships are maintained with all the major Italian universities plus leading US technical universities such as MIT, the University of California at Berkeley, Carnegie Mellon and Columbia. At any given time, more than 100 interns working on their theses at STMicroelectronics. Employees develop ongoing relationships with their alma maters. STMicroelectronics' other university relationships include working on research with individual professors; participating in academic conferences; providing lessons, tutoring and technical support, supporting scholarships; and participating in alliances, collaborative think-tank institutions and consortia.

The retention of employees is somewhat cultural. In Italy, HR executives told us, people do not move from company to company much since Italians tend to prefer to stay in their hometowns and regions. In addition, there are not many employment alternatives to STMicroelectronics in many of their locations. Thus, it is generally easier to recruit locally. Language differences also keep people from moving around significantly, and salary in Italy is not yet high enough to attract Northern

Europeans. The result is that EU-stimulated mobility is not yet a real issue. R&D executives suggested several times to us that they viewed cultural diversity as a competitive asset, but this relative immobility of the European labor pool made us wonder how STMicroelectronics promoted this workforce diversity.

The company's number one motivator, we were told, is giving people interesting technical work that correlates to the employees' interests. Management tries to avoid layoffs and was mostly able to do so during the recent technology sector downturn. The firm also has stock option/purchase programs, which are competitive in Italy but did not to us appear as attractive as similar programs in the US.

Some guiding principles they use in developing and managing their human resources include: building shared values [we were impressed with the degree to which corporate culture was unified, despite the long history of mergers and acquisitions]; creating leadership development models; using differences to be better than before; keeping balance in mind and not overvaluing any one thing (e.g., technical expertise, culture, any one style, etc.).

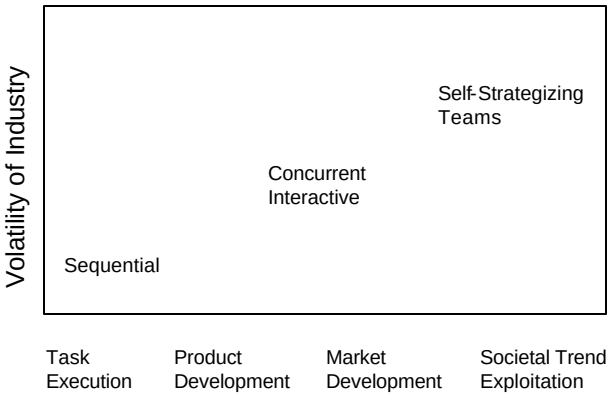
Another HR tool was to create ST University to provide employees with skills, knowledge, and explicitly--interestingly to us--cultural adaptability. The ST University provides job specific programs, personal development plans, tools and methodologies.

Telecom Italia Labs

The nature of the work in Telecom Italia research labs (TIL) changed when Telecom Italia moved from a government-owned monopoly to competing for service. They were no longer able to do in-depth research on technologies without looking at marketability. This, in turn, changed their approach to talent acquisition. Now they are looking more for people who can handle the Development side not just the Research side of "R&D." They are looking for a mix of capabilities. They have been working to inject a new set of lab employees with these diverse skills, while maintaining a subset of the more pure research employees. According to the Director, they have succeeded in moving to a more Development focus, although they have had difficulty with some long-term research employees who have struggled to adapt to the change.

Unilever

Among the most interesting discussions we had on our study mission involved Unilever's thinking about how to organize R&D around consumers, rather than technologies or products. They showed us a conceptual map, shown here, of different processes for organizing R&D teams and projects, which depended on the narrowness of the R&D task and volatility of the industry.



For example, narrowly defined tasks in stable industries were done using typical sequential milestones and deliverables, while much more flexible and self-directing cross disciplinary teams tackled broad envisioning programs aimed at moving the company towards identifying and exploiting emerging social trends.

A related significant R&D management emphasis in terms of building employee skills is in trying to get laboratory scientists to understand consumers and consumer needs. Because there are so many complex and peripheral cultural and social effects that determine customers' responses to food, Unilever not only hires top scientists but also anthropologists, social scientists, etc.

Preferences for food are essentially non-cognitive--consumers do not know why they like what they like. As a result, it is remarkably difficult to isolate variables that affect consumer preferences. Food researchers have to study sensory analysis, nutrition, food functionality and social mechanisms influencing choice and preferences. As one example of this research, our Study Mission group got a tour of a taste bud research lab. The research being was not revolutionary breakthrough science, but was highly technical nonetheless, and quite applied to better understanding consumer preferences (e.g.

actual taste buds were tested to make detailed computer-generated "maps" of taste responses for different foods/flavors). We appreciated the example of what research in a food company is.

We asked two scientists we met about why they choose to work at Unilever, and both said that they liked seeing tangible results of R&D. We were also impressed that both these mid-level bench scientists seemed to clearly understand how their work fit into the broader corporate strategy. We quietly wondered among ourselves whether mid-level laboratory people in our own organizations would be as capable of articulating how their work fit into the broader strategic vision.

Unilever had an interesting approach to introducing new employees in the company. New employees spend three weeks coming up with a business plan for Unilever, complete with financial projections and marketing strategies. There is considerable emphasis on getting a big picture view, and on encouraging employees to form and voice opinions beyond their formal job descriptions.

Topic 4: 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.

- How do you determine what R&D should be done with what resources in each location?
- How do you organize, integrate and allocate project responsibilities among geographically dispersed new product development teams?

Topic 4: 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 Study Mission 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. The notable exception was the smaller company SAES Getters. 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. Unilever to understand local food preferences). 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, except at Merck, 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, Daimler's acquisition of Chrysler (US) gave that company an R&D presence in the US, and STMicroelectronics had consolidated multiple firms over the last decade, resulting in broadly distributed R&D activities, yet strongly directed from the center. We note with some interest that DaimlerChrysler unifies the many divergent research activities through its "Scenario 2020" vision, and cascading that vision down through the organization. We also were impressed with the innovative flexibility with which Unilever corporate R&D managers set its R&D strategic direction for central competencies but allowed its consumer-oriented brand/local development groups to manage product development tailored for local preferences. We also note that Philips had moved to become more centralized, by relocating to new central R&D facilities on a university-like campus. Merck was the opposite, with no central R&D at all, just a small coordinating technology office.

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 3, although the EU has created some sense of international unity among member countries, a deep-rooted national pride and preference for staying local 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., Merck and Telecom Italia). Firms from the smaller countries (e.g., Philips and ASML) seemed less nationally oriented, as did conglomerates that resulted from international mergers (Daimler Chrysler, STMicroelectronics). Unilever and Schlumberger had quite the opposite feeling, of remarkably diverse and global organizations. 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 national roots were observed in organizations such as Telecom Italia, which was trying, although against (to us) obviously considerable cultural inertia, to transition from an Italian company doing business internationally to a global company with an Italian flair. Finally, STMicroelectronics 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.

DaimlerChrysler seemed to have some impressive direction in managing distributed R&D operations. Their research labs are set up locations to be near technology explosions as it makes sense. For example, as the Internet and related telematic technologies started to take off, executives considered how that might affect vehicles. They created a lab location in Palo Alto, within the Silicon Valley region where those technologies were most actively emerging.

Schlumberger had an interesting approach to their remarkably decentralized operations, leveraging that decentralization into a competitive advantage by incorporating diversity centrally into their innovation strategies. They tried to match the number of employees at a particular location with the number of employees with that location's ethnicity hired into the company. So, for example, if they had an office location in Kazakhstan with 50 employees, Schlumberger would work to have around 50 Kazakhstan employees somewhere throughout the company. Some at the specific geographic location, of course, but many others spread out across the world. This type of diversity and cross-cultural mobility can help to manage relationships and improve communication across diverse international locations.

Another general observation was that we heard several times that the most successful technology transfers from group to group came from exchanging people. Intellectual property does not transfer very well without people having the (tacit) knowledge to go with the technology and stay with it until it is fully integrated into a business unit's operations. Many firms had policies in place to transfer people from the central R&D function into the business units where the technology was needed. Philips, STMicroelectronics, Schlumberger, Fiat and Unilever research engineers would be transferred for some finite period to integrate their technology into other business units. An added benefit was that such transfers that gave the researcher first-hand experience with applications in the field.

In the majority of our visits, we were continually impressed with the abilities of Project Managers. In our opinion, Project Managers at the companies we visited were more capable than typical PM's in the US. It is important to point out that several of the organizations worked on very large-scale projects, so the scope of the PM role was considerably broader than typical PM roles in the US. However, all of the PMs were very involved with business issues – most projects required the PM to develop a business plan, not just do scheduling and resource planning.

A final take-away was the strong degree of cross-functional and international collaboration among the European firms. While the reasons for cross-functional involvement are obvious, the degree of international collaboration was somewhat new to us as students and US-based technology managers. Some of the focus on international collaboration was cultural and a bit of it related to the impetus provided by the EU to make Europe more competitive. The major drivers, however, were competitive strategy and competency building. Related to collaboration was several firms' focus on motivating employees by matching their capabilities with so-called "interesting" work. This involved getting like-

minded engineers and scientists collaborating from other business units or companies on a shared technical or business challenge. A number of our host companies made specific mention of this fact as key to their innovation activities.

The following excerpts from the participants' notes on some of the site visits reflect additional reflections on Topic 4.

CERN

By necessity of scale, CERN equipment and experimental operations are centralized at the CERN laboratories. However, all programs involve collaboration with various institutions in education, government and industry, so much of the actual design and data analysis work (program execution) is inherently decentralized. Operations management, program coordination and system integration tasks are centralized activities. The "Grid" project is an example of an inherently distributed project that has a centralized management structure within CERN.

A fairly new problem for CERN along these lines is in working not only with university scientists throughout the world, but also with industry. CERN is being pushed to manage its activities closely so member states can be assured of value/return. Because of CERN's role in the World Wide Web, the reputation has led to expanding collaboration with industry. CERN has increasingly been promoting the potential market benefits of their world-class scientific and technical activities to companies. CERN can act as the high-risk R&D activity for companies. However, particularly when compared with the pace of large-scale energy research, industry looks to quickly develop marketable technologies, so communication, accountability and clarity of research mission become important issues.

DaimlerChrysler

DaimlerChrysler has 1600 people dedicated to research, and distributes these resources around the world. DaimlerChrysler establishes research centers where there are competencies and university relations focused on technologies key to DaimlerChrysler (e.g. Palo Alto for information technology and telematics and India for software).

There are multiple requirements to establish a research center:

- Cooperation with partners (usually requires existing relationships);
- University relationships;
- Available talent with specific competencies.

They have found technology transfer from research activities into business units challenging. They run into situations such as when R&D finishes a prototype the business unit claims to have wanted something different or sooner. They believed that the larger and more diversified a company is, the better chance there is of key misunderstandings.

Eurescom

Eurescom executives believe they have developed an efficient structured system of decision making and monitoring, allowing their limited staff of managers to supervise hundreds of project participants across many countries in dozens of 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.

Eurescom's top managers believe that a critical factor in their success in managing collaborative projects is in developing project teams of people with experience in international and collaborative R&D. In particular, having several individuals with such experience on each project helps engender trust among otherwise competing companies. Although Eurescom provides the project administrative supervision, the project technical leadership comes from the participants. Administratively, "program managers," who are from Eurescom, play the role of selecting and managing participants as projects evolve. Eurescom program managers are required to have past experience/success with international projects and relevant research experience, coupled with good communications skills (e.g. attitude, language). However, the success of the project ultimately rests with the "project managers," who are usually from the participating companies and who make most of the critical operational decisions.

Eurescom has developed a custom IT management system to assist participating companies share information in a secure manner. 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 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 several times annually. Communication between employees of participating companies is both through EURESCOM and direct communication between member companies. In the final analysis, researchers want to communicate freely between each other. So the technical tools notwithstanding, they will use whatever communication medium is easiest for them. Getting to know each other informally at the face-to-face sessions significantly improves these informal channels of communication. Eurescom's picturesque location in a grand historic villa overlooking Heidelberg helps promote interest in and a friendly atmosphere for these meetings.

Merck

Merck uses a ten-person central "Office of Technology" to coordinate the activities of the different R&D labs. They have connections with universities, including MIT. The Office of Technology also deals with technology evaluation and alliances, with a particular focus in chemistry and chemical engineering.

There is no central R&D at Merck as each business unit performs their own research with specific products in mind. Technology is transferred between regions/countries through the transfer of R&D personnel to areas where their expertise is needed.

Philips Research

Research within Philips is handled on a worldwide basis, however we had only limited discussion of management of decentralized operations. Quite the contrary. We note with interest that when we visited, Philips was actively moving away from distributed innovation activities, both organizationally and physically. Philips had constructed a far more centralized R&D campus near Eindhoven, bringing together what had been more dispersed activities. Managers believe the campus is more efficient operationally, facilitates better cross-discipline and cross-project communications—particularly for sharing and transferring tacit knowledge—and is 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. As they move, they bring their knowledge with them, facilitating intra-company technology transfer. However, Philips indicated that moving research people with their product all the way through to the final commercialization phases did not work, because the skill sets and interests were often too different.

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 information needs across these—in particular, to gather and share information from customers. Yet, existing customers in many markets generally are not the users who dictate technology change. So, relying on existing customers risks missing emerging trends. Japan tends to have rapidly moving and leading edge tastes for high-technology consumer electronic products. Therefore, Philips attempts more trial-phase products in Japan than in Europe or the US, and then eliminates the products 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. Yet, 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.

Saint-Gobain

Saint-Gobain is a global company. However, despite being globally dispersed, R&D at Saint-Gobain is relatively centrally controlled through a rigorous and holistic three-level decision making process. Saint-Gobain managers that feel strong and efficient communications and effective program management are required competencies to be successful in this model. For the decentralized R&D functions, Saint-Gobain managers match competencies of the division with the requirements of the R&D program when assigning roles and responsibilities.

A lot of coordination and technology transfer is accommodated by travel. Travel is used extensively by Saint-Gobain for cross-pollination of skills, competencies and technologies within the organization. They stated that this is why they value a diverse and international workforce. They try to recruit individuals who want to travel, and all employees understand that significant travel is an expectation. Short and long-term business trips are used extensively to ensure that coordination and integration activities go smoothly.

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 geographically 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. About 75% of its R&D is controlled largely by the branches and is focused on shorter-term objectives specific to that branch. The remaining 25% of R&D is controlled by the VP of R&D and is aimed at Saint-Gobain's longer-term objectives, independent of branch.

Even though only ¼ of the budget is directly controlled centrally, the overall R&D portfolio is nevertheless strongly centrally managed. 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.

In decision making about allocating resources across it far-flung R&D activities, Saint-Gobain considers a multitude of performance metrics. These include: 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.

We initially found this centralize-everything outlook somewhat insular, but upon reflection it is hard to quibble with a strategy that maintains an 80% market share. Perhaps this strict design centralization works for SAES more than it might for our companies because of their relatively small scale compared to our firms.

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 collaboration 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 in Topic 3, that provides additional motivation—particularly for engineers. They are given incentives based on 50-percent individual performance and 50-percent business-related bonuses.

STMicroelectronics

The company employs a highly distributed organizational structure that reflects its global reach. STMicroelectronics' facilities include manufacturing operations in China, the Czech Republic, France, Italy, Malaysia, Malta, Morocco, Singapore and the US, with additional design centers in Finland, Germany, India, Israel, Japan, South Korea, Spain, Switzerland, Taiwan and the UK. The company has more than 70 sales offices in about 30 countries.

They were very comfortable with having R&D all over the world. They stressed communication and the need to keep information barriers between different geographies low. We got the distinct impression that there were high levels of communication between different R&D sites, done via teleconferencing, etc. Although the subject did not explicitly arise, we got the impression that STMicroelectronics' 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. However, in contrast to some of our other visits, there did not appear to be a high degree of actual people mobility.

Like Saint-Gobain, STMicroelectronics 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. STMicroelectronics has a global R&D presence; its R&D facilities are in the US, Europe and the Far East. There is manufacturing in Asia is for cost reasons as well as market proximity. They have 3000 people in central R&D located in 12 design centers. R&D is located where the competencies exist, though Italians like to work in the region of their home. There are four R&D facilities in Italy and Central R&D has headquarters in both France and Italy where the original parts of the now-combined company started. STMicroelectronics has a distributed R&D function so they can be close to the market and develop competencies related to their various market regions. 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 these development centers. The activities in each center are driven by and managed according to each site's mission and budget. 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 STMicroelectronics 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 STMicroelectronics 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.

Total

R&D at Total is distributed throughout the world determined by the needs of the individual divisions. Each division has its own R&D function, with funding controlled at the corporate level. Total has only limited R&D activity centrally. The central role is mostly strategic direction. Corporate R&D ensures compliance with environmental regulations, but is primarily responsible for overseeing the portfolio, so that the many specific R&D programs, when taken together, fit the overall corporate mission. Total makes intensive use of its intranet to communicate within the company and to tie the diverse R&D community together.

All divisions (at least in oil and gas operations) have their own risk assessment department that assesses environmental and economic risks.

Unilever

Unilever thinks of decentralized R&D activities as a competitive necessity. Because so much of the business of food and flavors and brands is strongly culturally dependent, local product differentiation is critical to commercial success. In broad terms, Unilever categorized how they saw regional differences in food preferences in terms of flavor and culture:

- Mediterranean: tomato, garlic
- Russia, Europe: meat, cream
- Africa: spices, garlic, tomato
- Asia: fermented sauces, spices
- North America/Australia: multicultural immigrant

Within these large regions, there is also considerable local differentiation. Organizing R&D to deal with such diverse and local preferences, while at the same time taking advantage of Unilever's global scale and the scope of its expertise, is a major goal and challenge to R&D management. As a result, they need, they believe, a volatile organization model that combines two attributes. First, teams focused at the local level that intimately understand local habits and attitudes and can innovate and bring locally differentiated products to market quickly. This is combined, second, with a global system of centralized expertise in some areas, principally: methods of understanding consumers, new product design, process control and improved functionality. This structure allows fast change, adaptability and mass customization.

Topic 5: 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.

- Which national and/or EU policies and institutions have the most significant affect on the management of technological innovation in your firm?
- How successful are the mechanisms you use to influence policy?
- What business and technology opportunities and threats do you see with respect to the ten-nation expansion of the EU?

Topic 5: Summary and Conclusions

Having been well briefed on EU institutions and cooperative R&D programs and as traveling Americans taking advantage of 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 CERN, MEDEA+ and TNO, which get significant support from national governments or the EU. Eurescom, too, had been offering their management experience in collaborative R&D programs on a contract basis to the EU collaborative R&D programs. Indeed, most of the organizations we visited had participated in significant R&D programs in part funded by the EU. Nonetheless, the EU funding generally was a minor fraction of overall R&D at these firms, and hence a generally minor issue for most of them. Even the relatively new joint European patenting system was largely unmentioned, which surprised us given the role of IP for most of our host firms.

Our lasting impression was that the firms seemed to take the now well-emerged EU environment and policymaking bodies almost for granted. Perhaps the EU generally represents 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 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 or Enron prosecutions—we also take for granted our government's significant role in helping US business operate efficiently.

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 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 Study Mission team noted a continuing strong sense of nationalism wherever we went, although perhaps somewhat diminished compared with Study Mission European visits in previous years.

Our impression with respect to the EU might be illustrated by the difference we perceived between Fiat and DaimlerChrysler. Fiat, which we sensed was struggling to find successful strategic direction in remarkably competitive global auto markets, seemed to be chasing EU programs in an effort to gain some level of revenue. Specifically they spoke about the EU recommendations for reduction of deaths, and getting funding for the different "active" computer technologies necessary to make it

happen. On the other hand, as we mention in Topic 3, Fiat did seem to have developed a world-class human resources management system through a collaborative program funded by the EU.

On the other side, DaimlerChrysler had almost no interest in EU programs. Their ability to make money seemed to limit the need to focus on those programs. However, during an informal discussion before the Study Mission session, one of the DC representatives mentioned that they had actually gone to the EU with recommendations on vehicle safety technologies that could be used to reduce traffic fatalities. While we are unable to validate this, DC apparently created some "active" technologies that could make cars safer. They then went to the EU to suggest that the EU should push related regulation to reduce traffic fatalities. This, they hoped, would force other companies to either expend research dollars or license DC's technologies.

By strong contrast, government funding and influence on the policy process were essentially the lifeblood for TNO. With a Dutch government-mandated mission to contribute through R&D to the competitiveness of Dutch firms, and with both public and private funding, TNO operates squarely between business and government. Its board is even appointed by the government. However, as we mentioned under Topic 1, its national-economy-wide mission did—to us—seem to lead TNO to try to support an unsustainably broad list of "strategic" or "core" technologies, given the scale of its budget. On the other hand, TNO does appear to have a worldwide reputation for scientific excellence, and we were interested in learning more about whether any studies had been done evaluating its impact on Dutch competitiveness. Perhaps our American policymakers could learn effective budget-efficient techniques from TNO for supporting industry.

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

ASML

ASML is truly a global company, with a strong presence in the US as well as in its home base in Europe. Despite our knowledge that ASML has actively participated in a significant number of EU R&D projects, there was no specific discussion on the effects of the EU policies on operations, nor of potential plans to leverage the eastward EU expansion.

ASML uses government subsidies to help fund its R&D investments. Executives estimated that subsidies accounted for 10-20% of its R&D budget. A large fraction, above 2/3, of the government funding is from Dutch government. Technology Development Credits (TOKs) are repaid when the technology is delivered to the market and generates revenue. ASML is also a preferred partner of the partially Dutch government-funded long-range semiconductor research organization, IMEC. IMEC uses ASML lithography equipment (obtaining it relatively inexpensively). In return, ASML obtains process technology expertise from IMEC. ASML has some engineers on site at IMEC.

In terms of the broader business environment in Europe, ASML's geographic and cultural proximity to IMEC, Philips 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, its major competitors, 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.

CERN

CERN is a European joint venture for fundamental research on particle physics, and public funding is the main support for its operations. More than 6500 scientists from over 500 universities across 20 member states and nine observer states (including the US), contribute to CERN programs. Representatives from the 20 member states sit on the board and council for CERN. The Council is the highest authority and has the ultimate responsibility for all important decisions. They control CERN's activities in scientific, technical and administrative matters, thus providing input relative to the S&T policies from the various European governments. None of the member states has more pull than others, although funding can vary significantly (based upon GNP). Member states obviously have more influence than observer states.

DaimlerChrysler

DaimlerChrysler operates in all EU countries as well as in a large number of countries outside the EU (USA, Russia, etc.) and each country has unique challenges and opportunities. DC strategy is to position themselves at the leading edge of research, and as a truly global, not European firm. As a result, they were less interested in collaborative work through EU programs, except were they could influence standards.

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, literally hundreds of telecommunications operators now compete 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 potentially 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 many competing 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. The European Framework and the non-EU EUREKA program have had the biggest impact in terms of funding. These are public funded programs supporting primarily pre-competitive R&D to improve European competitiveness. Because EU and EUREKA subsidies to companies require collaboration across national borders, the R&D management skills are substantially different. Therefore, Eurescom executives believe their experience managing many international telecom R&D projects has given them a comparative advantage in international collaborative R&D management. They have actively been pursuing such R&D management contracts through the EU. It was unclear to us the degree of success they have had in that pursuit.

Fiat Research Labs

Of all the organizations we visited, EU programs seemed most central to Fiat's central research labs. Fully 20% of CRF's R&D budget is coming under contract from EU Fifth Framework Programme. This struck us as surprisingly high, and we wondered about the degree to which Fiat was making ad hoc tactical R&D decisions to chase public R&D funding, rather than directing R&D more strategically. Total CRF funding is a result of "customer contracts" stemming from the EU, Fiat Group funding and local public program funding. Local program funding means research funds stemming from Italian participation EUREKA and other inter-regional programs. According to lab executives, this is a great source of R&D funds, but payments are more difficult to realize than those coming from the EU.

As we mentioned in Topic 3, Fiat's current formalized system for managing human resources, process management, product planning and knowledge integration, called COMPETE, which we found to be excellent, was developed collaboratively with other European partners as a part of an EU-funded project.

MEDEA+

MEDEA+ has a similar organizational role in facilitating cooperative R&D across Europe as EURESCOM but is focused on microelectronics instead of telecommunications. More importantly, it was apparent that because of its historical roots in the JESSI and ESPRIT/EU Framework programs, MEDEA+ is much better connected with the EU and is able to extract money from both the EU and participating firms. While MEDEA+ has 226 participating firms, EURESCOM has only 15.

Philips Research

The impacts of the government were not directly discussed. There was some mention of the fact that Philips represents a significant portion of research for all of the Netherlands and that gives them some influence. However, the government tries to avoid being seen as giving Philips favoritism, so the benefits are not as high. Like at ASML, we were surprised that EU programs were not higher on the radar screen at Philips, given our understanding of their 20+ year history of participation on EU R&D policy

steering committees and in EU-funded collaborative R&D projects, particularly in information technologies.

SAES Getters

SAES has a strong intellectual property position, which is protected by the EU policies. They also have developed a strong collaboration with universities for basic research.

Telecom Italia Labs

We did not discuss the EU and its impact. However, the discussions above in Topics 2 and 3 on alliances and managing talent present the impacts of the move away from a state owned Monopoly.

TNO

TNO is a public organization operating at the interface between government and business. TNO is an independent contract research organization established by Dutch law for the development of Dutch industry and government and therefore is in fact a product of a government program. The group's mission is to make a substantial contribution to the competitive power of companies and organizations, to the Dutch economy, and to the quality of society as whole through scientific knowledge with the aim of strengthening the innovative power of industry and government. TNO also provides R&D services to Dutch local and national authorities. The Dutch government appoints the board of management and supervisors. TNO has a four-year strategic plan.

This research organization translates the results of fundamental research into practical applications on a commercial basis. They maintain a close relationship worldwide with the academic world in which new knowledge is generated, and with industrial R&D labs and companies where knowledge is applied to products and processes. Promotional and marketing offices located in Japan, Central and Eastern Europe and the US support its international presence.

TNO funding comes from the private sector and from the government, but the group has no obligation to give back any revenue to the funding institutes. Target funding by the Ministry of Economic Affairs takes place via the TNO co-financing program, whose aim is to foster innovative work with the business world. Depending on the degree of the innovation the program funds between 50 and 90% of project costs. About 10% of TNO's revenue is re-invested into building its base of core R&D expertise.

TNO R&D activities are all over The Netherlands and strongly intertwined with government activities. They include: the development of knowledge; the utilization of knowledge in industry and government; technology transfer especially to small and medium-sized enterprises; acting as a principal laboratories for ministry of defense and other ministries; for the commercialization of knowledge in cooperation with companies. The group focuses on five core business areas: quality of life; defense and public safety; advanced product–processes and systems; natural and built environment; and information and communication technologies. One of their main current focus areas is defense technology (bio-terrorism, homeland defense)--which is a product of the current environment in Western Europe and internationally.

Total

The major government impact on Total has to do with environmental regulation. Indeed, environmental regulations are the largest technology driver in the oil refining industry as a whole—specifically, controls on lead and sulfur content. Total R&D executives stressed to us that theirs is an environmentally aware company, and that they are positioning the firm for the future of low emission fuels and alternative renewable resources. The firm maintains a focus on environmental legislation and rules as well as emerging trends so not to be "caught off guard."

Transportation accounts for approximately 30% of worldwide energy consumption. Total feels that bio-fuels are a good alternative source for some transportation fuels, but that the biomass required to replace all worldwide needs would be unmanageably large.

C. Conclusions

To summarize the Study Mission experience and the various topics we explored, we conclude with our most lasting impressions. First, we compared our impressions with those of participants in the previous NTU Study Mission to Europe two years before: we got significantly different impressions. Two years ago, the European Union was a topic of much of the discussion, although somewhat taken for granted. The Euro had just been introduced and the impact on trade in Europe was unknown. This was a topic of even less interest during this visit. Much of the tone of the visit was set by the current economic climate with companies working to weather the current worldwide recession. Firms were quite focused on strategy as the key to success in the current economic climate. DaimlerChrysler, STMicroelectronics, ASML, Unilever and Saint-Gobain all had impressive methods for communicating the company strategy down through the organization.

Innovation Systems (Stage-Gate, Portfolio Management, HR)

As noted by the previous NTU Study Mission, considerable attention has shifted to inspiring and supporting innovation. Two areas mentioned frequently were the project selection and the project tracking methods. Most firms had a formal process to balance investments across near-term, medium-term and long-term product ideas. The goal was to provide business units with steady streams of new technologies to meet their future business goals. Though few companies we visited had many investments in purely radical (white-space) concepts, technology managers mentioned they used either bubble diagrams (risk/reward) or Monte Carlo simulation to measure the value of new project ideas and to balance their portfolios. Portfolio management techniques have been widely adopted in Europe.

Innovative ideas tended to be screened by only a few, high level, individuals, though the inputs came from numerous sources. The early screeners tended to be senior technology managers with close ties to the business. Implied here is that the senior managers supported the more innovative ideas as well. Those ideas, passing initial screens, then engaged broader groups to balance technical innovation with financial return.

Most of the companies use some variation of a stages-and-gates decision-making process for technology and new product development, though their implementations varied widely. It appears to be a relatively recently adopted method as there was little explicit feedback or evidence available on the methods' success.

European companies we visited were not just focused on short-term deliverables – they gave their employees considerable freedom to experiment and take risks. It reminded some of our Study Mission participants of the way HP used to operate. This kind of freedom and support was thought to be a key ingredient for innovation and knowledge accumulation. Over the past few years, the technology recession economy has resulted in layoffs and cutbacks that force more work on less people. This, in turn, has led to short-term "get it out the door" environments within the corporate America we see, and it seems that it has had (or will have) a negative impact on innovation. A take-away for us was that our US firms should work to restore the experiment/exploration risk-taking mentality, and hopefully, restore an environment that fosters innovation.

It was somewhat reassuring to see that all companies, not just ours, struggle with technology management and with leveraging core competencies into top line growth. The approach used for each company was different depending on their business segment and organizational culture. It is hard enough in good economic times to justify spending money on riskier technologies, which have low or long-term commercialization prospects. It is even harder to invest in riskier technologies when shareholders demand a growing bottom line. However, creating the right mix of incremental, innovative and highly innovative (blue, gray and white-space) opportunities with the available R&D budget seemed to keep the innovation engine alive in the firms we visited. We saw the best examples of this mix at SAES Getters, Merck, Unilever and Philips Research. These firms had a range of technology investments with varying levels of risk.

We reiterate that we were impressed by the processes at both STMicroelectronics and Schlumberger of sincerely valuing diversity and of developing and maintaining cohesive corporate cultures. The R&D management teams at both firms focused on corporate culture rather than geography or background. More than our US firms (our rhetoric notwithstanding), those firms' managers truly respect the diversity that their worldwide organizations 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, STMicroelectronics has moved from the second tier to being a major force in world semiconductor markets and Schlumberger leads in oilfield services. We now remain scratching our collective heads, trying yet unsuccessfully to envision a process for fostering such effective cohesive innovation cultures in our own organizations.

Technology Transfer

Technology transfer was an area where many firms excelled. We have never seen technology transfer taken so seriously in the US. European companies appear to have more experience with collaborating at the R&D level than most US firms. Several companies had detailed and comprehensive processes for technology transfer and many of them required the resources and people to be transferred with the technology to ensure that the transition was smooth with a limited 're-learning' curve. We were impressed with their ability to transfer technology efficiently and effectively from the 'R' side of R&D to the 'D' side.

To reiterate a key observation, the most successful technology transfers came from exchanging people. Intellectual property does not transfer very well without people having the (tacit) knowledge to go with the technology and stay with it until it is fully integrated into the business unit's operations. Many firms transferred people from the central R&D function into the business unit where the technology was needed. Philips, STMicroelectronics, Schlumberger, Fiat and Unilever all expected research engineers to transfer in order to more efficiently integrate their technology into other business units. We thought our American firms could learn a lot about technology transfer from these companies.

Collaboration

As noted in past NTU Study Mission reports, another take-away was the strong degree of cross-functional and international collaboration among the European firms. While the reasons for cross-functional involvement are obvious, the degree of international collaboration was somewhat new to us as US technology managers. Some of the focus on international collaboration was cultural and some of it related to the impetus provided by the EU to make Europe simultaneously more integrated and competitive. Related to collaboration was our host firms' focus on motivating employees by matching their capabilities with so-called "interesting" work. This key to their innovation activities involved getting like-minded engineers and scientists collaborating from other business units or companies on a shared technical or business challenge.

We note again our lasting impression of how critical collaborating 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, stage mechanics and metrology. 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). Moreover, beyond simple outsourcing, ASML invests heavily in creating, nurturing and managing these key partnerships.

Project Management

In the majority of our visits, we were continually impressed with the abilities of Project Managers. Project Managers at the companies we visited were more capable than typical PM's in the US. It is important to point out that several of the companies worked on very large-scale projects, so the scope of the PM role was considerably broader than typical PM roles in the US. However, all of the PMs were very involved with business issues – most projects required the PM to develop a business plan, not just do

scheduling and resource planning. American firms should take this to heart and work to develop similar capabilities in their PMs.

Metrics

We were also impressed by the focus on metrics at many of our host companies. Nearly all of the companies appeared to have internalized that "you only get what you measure." They have established metrics for everything from tech-transfer effectiveness to R&D performance. The latter is impressive because our own experiences as R&D managers suggest that this is a very difficult task. Our own organizations have been working for a long time on defining new and improved metrics. It was reassuring to get a first-hand look at what several European companies are doing in this area – it reaffirms the importance of the work we are doing in this area.

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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The 2003 International Study Mission was the sixth international study trip sponsored by the National Technological University's Management of Technology Program. We are grateful for the assistance provided by many individuals, companies, and organizations in the US and Europe.

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The participants are especially grateful for the support provided by the organizations with students in the European team of the NTU/MOT program this year, including Agilent, Hewlett-Packard and IBM.

So too, we cannot fully express our enormous debt to Nico Hazewindus, who was by far the primary individual helping to make our International Study Mission the great success we believe it was. The success of the European 2003 NTU Study Mission is very largely a result of Nico's hard work and dedication in the final months of finalizing the agenda, and is a tribute to the personal and professional relationships he has fostered throughout his career. The itinerary he created carefully balanced our desire to see many organizations across much geography with our wish to avoid traveling to a new location every day. The resulting mix was just right. The diversity of our visits and hosts added much to the value of the trip—public and private institutions, small companies and large corporations, a diverse industry mix (semi-conductor/microelectronics, automotive, consumer electronics, glass, chemical, and telecommunications), and cultural differences among firms across countries. The experts Nico assembled for our visits were incredible; we were impressed with the number, the level, and the knowledge of individuals assembled to meet with us, and we were amazed at the level of preparation and time they were willing to put in for our visits. And, finally, a special thanks to Nico and his wife for going well above the call of duty and inviting us all into their home for a delicious dinner at the peak of white asparagus season! The hospitality and generosity were sincerely and most deeply appreciated.

Nico worked closely with the travel agency Teletours, whom we thank for their timely help in arranging for lodging, tickets and other reservations, and for their patience with us during several billing delays.

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Sonia Escaffre, Secretary to Dr. Hoffmann
Dr. Francois Grey, Open Lab Development, IT Division
Dr. Florian Sonnemann: Strategic Planning, Directorate Service

DaimlerChrysler
Dr. Horst Soboll, Director, Research Policy and Communications
Dr. Gösta Pfundtner, Research Policy and Communications

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Dr. Claudio Carrelli, Director
Milon Gupta, Public Relations Officer

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Dr. Ing. Luciano Pera, Executive Vice President, Research Promotion
Gianni Mora, Director, Business Information Technology
Andrea Campiglia, Human Resources
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Prof. Dr. J.H.W. de Wit, Board of Management
Geert Schoch, Director, International Projects, Commercial & Legal Affairs

Total
Dr. Claude Jablon, Senior Vice President, Scientific Development

Unilever
Dr. Jan de Rooij, Director, R&D
Dr. Jan Maat, Principal Scientist, External Research

APPENDIX A: OBJECTIVES AND ITINERARY

The purpose of the National Technological University (NTU) Management of Technology (MOT) Program of 2003 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 2003 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 and 2001, Japan in 1993 and 1995, and the 1997 trip to both Japan and Korea. As in the past, the participants in the 2003 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 2003 Study Mission are technical managers working in major US industrial firms and enrolled in an Executive Master's of Science program at NTU. The team members will be accompanied and led by an MOT faculty member. (See *Study Mission Team* list.)

During the 2003 International Study Mission, the team members will visit companies in Northern 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 consumer electronics firm
- A telecommunications provider
- A consumer products company;
- A small company with global position.
- A high-energy physics research facility

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The 2003 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 2003 International Study Mission objectives will be accomplished through lectures, company site visits and informal discussions. While in Europe, the Study Mission team will visit 16 industrial companies; 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 2003 Study Mission group includes:

- 1 MOT faculty leader
- 6 technical managers/graduate students
- 1–2 guests (industrial managers)

Study Mission Leadership
Faculty Leaders:

Professor Todd A. Watkins of Lehigh University will lead the 2003 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.

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.

Study Mission Sponsors:

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

APPENDIX B: TOPICS FOR DISCUSSION

Questions: These were the questions sent to the companies and form the basis of this report.

Topic 1: Strategic Direction of R&D/Management of Technological Innovation (MOTI)
In our technology-based US firms, we find effectively managing the R&D function and the technological innovation process requires a close integration with competitive/business strategy.

- How does your firm ensure that the R&D function is managed in a way that effectively supports your competitive/business strategy?
- What mechanisms do you use to identity emerging technology and business opportunities?
- How has your technology strategy changed in response to the significant worldwide slump in technology industries?
- Are disruptive technologies or radical/discontinuous innovation of special interest or importance to your firm? How do you promote your own or respond to competitors' disruptive technologies?
- With particular focus on MOTI, do you see particular strengths in the way you manage your customer relationships?

Topic 2: External Technology Acquisition through Networks, Alliances and Acquisition
In the US, we find that effectively leveraging the external relationships of our technology-based firm requires a close integration with competitive/business strategy.

- Given the potential costs involved, entering external relationships requires a compelling business case. Why do you seek the competencies externally rather than developing them internally?
- How do you select the firms you partner with?
- 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, responsibilities, accountability, resolving conflicts and ensuring effective communication?
- How do you measure the performance and effects of these external relationships?
- Do you have external relationships that work particularly well? What factors make the more successful relationships work, when compared with less successful ones?
- How do you manage and protect intellectual property in these relationships?
- How do you cooperate with competitors in such alliances/networks?

Topic 3: 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.

- How does your firm identify, recruit and retain scientifically and technically skilled people?
- How do you motivate, reward and promote them?
- How have you dealt with, during this technology business downturn, the tension between the needs to cutback and to retain technological skill-sets?
- Do you foresee near- or long-term problems of a shortage of scientists and engineers or in retaining your company's 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 4: 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.

- How do you determine what R&D should be done with what resources in each location?
- How do you organize, integrate and allocate project responsibilities among geographically dispersed new product development teams?

Topic 5: 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.

- Which national and/or EU policies and institutions have the most significant affect on the management of technological innovation in your firm?
- How successful are the mechanisms you use to influence policy?
- What business and technology opportunities and threats do you see with respect to the forthcoming 10-nation expansion of the EU?