STRATEGIC BUSINESS INSIGHTS

AREA SciencePark

SERVIZI DI BUSINESS INTELLIGENCE

tecnologie monitorate, abstract e modalità di accesso

Business Intelligence per le imprese: il servizio e gli obiettivi

Individuare i trend e le tecnologie emergenti per orientare in modo appropriato i progetti di ricerca e sviluppo, gli investimenti per la crescita della competitività, la nascita di una nuova impresa. A queste esigenze si rivolge il servizio di Business Intelligence messo a disposizione da AREA Science Park grazie all'accordo con SBI - Strategic Business Insights - http://www.strategicbusinessinsights.com -, leader mondiale nel monitoraggio delle tecnologie in grado di generare business. Questo servizio si avvale di strumenti fra i migliori a livello internazionale con l'obiettivo di:

⇒ sostenere i processi decisionali aziendali rivolti ad attività di pianificazione di nuovi prodotti e processi;
⇒ individuare in anticipo tecnologie emergenti e trend di sviluppo in modo da poter orientare al meglio gli investimenti e cogliere nuove opportunità di ampliamento del business.

Explorer

AREA Science Park mette a disposizione delle PMI del Friuli Venezia Giulia ***Explorer***, uno strumento di Business Intelligence sviluppato da SBI che consente di **ottenere informazioni mirate su oltre 30 settori tecnologici**. Unico al mondo per affidabilità e ampiezza dei campi esaminati, Explorer offre inoltre l'opportunità di valutare le interazioni tecnologiche tra un settore e l'altro. Le analisi, **costantemente aggiornate**, costituiscono una fonte preziosa di informazioni utili ad individuare **opportunità** e **minacce** presenti nel mercato. Il passaggio dallo stadio di ricerca a quello commerciale delle tecnologie in rapida evoluzione viene infatti attentamente seguito da Explorer ed analizzato all'interno dei suoi report. La mappa tecnologica che questo strumento presenta è focalizzata sulla **commercializzazione della tecnologia** e offre una guida ai parametri di sviluppo che possono influenzarla, grazie ad un'analisi accurata delle principali implicazioni commerciali derivanti da potenziali salti o sviluppi tecnologici.
Grazie ad Explorer è possibile farsi un'idea sul potenziale di crescita di nuove tecnologie sufficientemente consolidabili e sulle loro potenziali **applicazioni al mercato**. Il servizio offre un valido supporto a chi deve valutare il futuro di tecnologie sviluppate in proprio o l'opportunità di sfruttamento commerciale, con l'acquisizione dei relativi diritti, di quelle emergenti.

Destinatari e vantaggi

Sono numerosi i vantaggi offerti dal servizio di Business Intelligence agli operatori del Friuli Venezia Giulia cui si rivolge:

- **Piccole e medie imprese**
  Viene offerta la possibilità di valutare in prospettiva qualità e competitività tecnologica dei propri prodotti attuali e futuri. Grazie **all'accesso gratuito ai report** Explorer, il cui costo sul mercato è difficilmente sostenibile per la singola azienda, anche le PMI del territorio possono avvalersi di risorse di business intelligence strategiche per la loro competitività.

- **Valutatori di progetti**
  Grazie ad Explorer è più facile essere informati a livello globale su "chi fa cosa", sulle nicchie di specializzazione e la distribuzione delle competenze nei diversi settori.

- **Operatori della formazione**
  Gli aggiornamenti in ambito scientifico e tecnologico offrono un valido supporto che contribuisce ad elevare la qualità dei programmi formativi.

Le tecnologie monitorate da Explorer (documentazione in lingua inglese)

- *Artificial Intelligence*
- *Biocatalysis*
- *Biomaterials*
- *Biopolymers*
- *Biosensors*
- *Connected Cars*
- *Connected Homes*
- *Engineering Polymers*
- *Flat-Panel Displays*
- *Fuel Cells*
- *Knowledge-Management Tools*
- *Membrane Separation*
- *MEMS/Micromachining*
- *Mobile Communications*
- *Nanobiotechnology*
- *Nanoelectronics*
- *Nanomaterials*
- *Novel Ceramics/Metallic Materials*
- *Optoelectronics/Photonics*
- *Organic Electronics*
- *Pervasive Computing*
- *Photovoltaics*
- *Polymer-Matrix Composites*
- *Portable Electronic Devices*
- *Portable Power*
- *Renewable Energy Technologies*
- *RFID Technologies*
- *Robotics*
- *Smart Materials*
- *Solid-State Microsensors*
- *User Interfaces*
- *Virtual Worlds*

- Intelligenza artificiale
- Biocatalisi
- Biomateriali
- Biopolimeri
- Biosensori
- Automobili intelligenti
- Case intelligenti
- Tecnopolimeri
- Monitor a schermo piatto
- Celle a combustibile
- Strumenti per la gestione della Conoscenza
- Separazione a membrana
- Micro-sistemi elettromeccanici
- Comunicazioni mobili
- Nanobiotecnologia
- Nanoelettronica
- Nanomateriali
- Materiali metallici/ceramici innovativi
- Optoelettronica/Fotonica
- Elettronica organica
- Sistemi elettronici pervasivi
- Impianti fotovoltaici
- Compositi a matrice polimerica
- Dispositivi elettronici portatili
- Fonti d’energia portatili
- Tecnologie delle energie rinnovabili
- Tecnologie RFID
- Robotica
- Materiali intelligenti
- Microsensori a stato solido
- Interfacce utenti
- Mondi virtuali

I Report: un esempio di indice e contenuti

TECHNOLOGY: SMART MATERIALS

Abstract delle 32 tecnologie monitorate - aggiornamento novembre 2009

Artificial Intelligence
(Intelligenza artificiale)

In some cases, when a task requires intelligence, artificial systems can do the job. Artificial speech recognition as well as face- and handwriting-recognition software rely on techniques that emerged from AI research. Other everyday applications of AI include a virtual pet that can learn from its experience and artificial characters in video games that change their skill level to adjust to a user's abilities. AI also enables autonomous vehicles such as those that run in DARPA Grand Challenges and European Land Robot Trials. Developers aim to solve increasingly difficult challenges—such as analyzing security-camera images and providing a humanlike agent that delivers natural-sounding speech answers to natural-language queries. Some software development aims to enable humanlike abilities—to translate speech and to guide robots to walk on unpredictable terrain and manipulate objects. Other AI development efforts aim at applying intelligence toward goals that would be difficult or impossible for people to achieve: Credit-card–authorization systems make fast decisions about whether to allow a purchase at a retail store, automated financial-trading systems arbitrage multiple stocks that a human could not keep track of, and AI software advises doctors in diagnosis, relying on knowledge bases that are more comprehensive than a person can reliably memorize. AI may even be evolving into an uncanny capability that does not emulate human intelligence but instead seems to have a mind of its own—as in the case of chess-playing computers, which have distinctly different styles of play from those of human chess players.

Researchers and developers take various approaches toward endowing artificial systems with intelligent attributes. The most mature approaches to AI simulate elements of human intelligence such as reasoning, learning, planning, and movement. Much research revolves around artificial reasoning: Software can prove or disprove mathematical propositions from axioms, and very similar software can make inferences about everyday matters from commonsense propositions in a rigorous formal language. A second family of approaches rests on the idea that intelligence may emerge from systems that emulate biological processes—systems such as artificial neural networks and genetic algorithms. Such methods appear in data mining, antenna design, simulation of crowd scenes in movies, and industrial-operations research. A third family of approaches that has yielded many practical AI-like applications arose from outside the mainstream of AI research, from the field of applied mathematics—especially statistics, probability, and optimization. And R&D in a field that's closely related to AI—the Semantic Web (whose advocates insist that it is "not AI")—aims to encode Web pages in machine-readable form, such that machines can determine the relationships among the concepts that are also in natural-language (human-readable) form. A Semantic Web inference engine can then draw conclusions, perhaps along the lines of "the spider cannot be a poisonous black widow because the university Web site indicates that all black widow spiders have red marks, and the student's Web site indicates that the spider in question is black and gray." Finally, a major direction for AI relies on combinations of all approaches or ad hoc approaches—anything that works—to perform tasks that people consider to demand intelligence.

Current progress in AI promises to enhance transportation and robotics, office productivity and collaboration, physical security and information security, transactions and logistics, entertainment and advertising delivery, and social interaction. Cars will rapidly respond to dangerous situations to avoid collision. Software will coordinate movements of service robots to perform useful tasks—perhaps gracefully. Personal-information agents will assist with scheduling and organizing meetings. Image-recognition systems will retrieve digital photographs, automate content production, alert people when security cameras capture events of interest, and provide context-sensitive information, entertainment, and advertising. Yet AI research also produces disappointments as developers encounter seemingly intractable problems such as language translation and commonsense reasoning. Visionaries and optimists may be disappointed with near-term projects to identify terrorists before they commit terrorist acts and to build robots that can provide safe and effective care of elderly and frail persons. But a good number of AI challenges are intermediate between intractable and feasible. Decision makers can benefit from monitoring advanced developments to reduce uncertainty about this large portfolio of intermediate-level problems. For example, different outcomes will result depending on the success of AI developers' efforts to manage risks in financial portfolios and credit decisions, generate content and advertising that is truly relevant to individual users at specific times and places, accept training from people who are not technology experts, and train robots to navigate through doors and handle food and drinks. Different outcomes could result depending on whether users will find software agents to be trustworthy when executing transactions, taking control of cars, and monitoring security cameras; whether people will consider that agents provide believable responses to conversational queries; and whether interacting with software agents in virtual environments is worthwhile.

Biocatalysis
(Biocatalisi)

Use of the metabolic pathways of microorganisms to catalyze chemical reactions in commercial processes—in competition with conventional inorganic catalysts—has become increasingly practical and affordable to many industries in recent years. Biocatalytic reactions are generally more energy efficient, have lower cost, and produce less hazardous waste than inorganic catalytic reactions. Biocatalysts have use in many sectors, including the food, textile, pharmaceutical, and chemical and energy industries. Within these industries, biocatalysts have many applications, ranging from product synthesis (for example, pharmaceutical and ethanol manufacture) through use as active agents in products (for example, in detergents) to use in diagnostic testing equipment and as therapeutic agents.

Biocatalysts have use in both industrial (commodity) and specialty (low-volume) applications. The attributes necessary to succeed in developing and selling these two distinct product types differ. Commodity applications work on high-volume production and are price sensitive. Often supplier/customer relationships are long-standing and difficult to break. Commodity biocatalyst users have a reputation for conservatism. Specialty biocatalysts sell in low volumes and are generally useful in applications where the enzyme is a small but value-added component or where addition of the enzyme either facilitates performance or leads to a performance improvement that justifies its cost of use. Such an application would be a therapeutic enzyme or an enzyme for use in a diagnostic kit. Areas showing a potential for market growth and for technological innovation include the development of engineered enzymes (providing faster throughput, cheaper production, or the capability to produce novel products), pollution-control systems or lower-polluting industrial processes (such as pulp and paper manufacture), nonaqueous biocatalytic systems (for use in applications such as oil and fat bioprocessing) and manufacturing processes for producing specific compounds (for example, biopharmaceuticals). Biocatalyst companies are now accelerating the advancement of biocatalyst and bioprocess knowledge to exploit these emerging opportunities. At the same time, successful companies understand that the exploitation of biocatalyst opportunities requires a long-term commitment. More and more companies in a variety of industry sectors are now investing significant research dollars in exploring biotech opportunities. The continued growth in interest in the commercial use of biocatalysis and continuing technological innovation coupled to the fragmentation of the biocatalyst industry allow both large and small companies to exploit innovative biocatalysts, products, and processes.

Biomaterials
(Biomateriali)

Biomaterials are substances (including polymers, metals, ceramics, and composites) that are produced synthetically or biologically for use in the treatment or management of a disease, condition, or injury. New R&D, testing methods, and manufacturing processes can lower the cost of developing new biomaterials. New breakthroughs in biocompatible materials and coatings can markedly lower the risk of device failure or adverse immune reactions. Improved devices and drug-delivery systems can improve health and lower long-term treatment costs to consumers and insurers. Broader markets, industry changes, population demographics, supply chains, health-care financing, tort reform/product-liability legislation, and international regulatory standards will all have a major impact on the profitability of biomaterials. This Technology Map examines how changes in technology and industry structure can affect the profitability of biomaterials in medical products.

Analysts from the EU Competitive and Sustainable Growth Program estimate that the worldwide market for biomaterials was some $23 billion in 2000 and predict that the market will grow some 12% per year. The United States is the major market, with a value of some $9 billion and a growth rate of 20%. Europe's market is some $6 billion.

Biomaterials feature in a range of established medical devices, such as implants to replace diseased joints, and as surgical-repair materials such as sutures and repair meshes. For these established products, continuing R&D will improve key requirements for the product, such as more durable joint implants. Such developments improve medical outcomes for patients, differentiate broadly similar products, and enable manufacturers to gain competitive advantage. Biomaterials also make a significant contribution in the growing field of drug-delivery systems. Biomaterials have properties that enhance drug delivery and provide technologies for alternative delivery routes and release mechanisms. Finely tuned drug delivery is becoming a reality with the support of biomaterials, particularly for the growing range of protein therapeutics emerging from research in genomics and proteomics.

Regenerative medicine offers patients products that repair or replace worn-out tissues. A range of applications for biomaterials in regenerative medicine are emerging in response to the aging population of the more economically advanced countries. Regenerative medicine will also benefit people with autoimmune and early-onset degenerative diseases and people who require treatment for trauma injuries. The first products (synthetic and natural biomaterial scaffolds to enable tissue repair and regeneration) were available commercially in 2000, but products such as tissue-engineered blood vessels and heart valves are not likely to be on the market before 2010.

For the foreseeable future, biomaterials will have an important place in medical technologies. Biomaterials have no shortage of potential applications in medical devices and drug-delivery systems. In the future, biomaterials may face competition from stem-cell technology that has the potential for "natural" replacement tissues and organs (that do not use biomaterials), but this technology is a distant and somewhat uncertain prospect. Three main factors constrain the expansion of the biomaterials market: the high costs of development and achieving regulatory approval, availability of funds to pay for more sophisticated and expensive health care, and the specter of litigation.

Biopolymers
(Biopolimeri)

Biopolymers are biologically produced polymers that have unique functional properties. Much of the uniqueness stems from the fact that chemists have difficulty producing these materials cost-effectively or in sufficient quantities because they have difficulty in reproducing the complex biosynthetic machinery of living organisms. Researchers have the technology to modify plants to produce enzymes, novel proteins, biopharmaceuticals, specialty chemicals, and polymers. Processors receive the harvested crop and recover the target compound from the plant matter, which can be leaves, stems, seeds, or storage organs. A major agricultural milestone will be the commercialization of transgenic plants that contain target compounds. In the future, manufacturers may produce novel biopolymers in this way, thereby avoiding the start-up costs of fermentation processes. Biopolymers have several functional uses: as stabilizers, thickeners, gellants, binders, dispersants, lubricants, adhesives, and drug-delivery agents. Most of these uses are in specialty applications.

Many biopolymers are in commercial use, and several developments promise to ensure growth for both existing and future applications. Some of these developments include concerns about plastic wastes, demands for convenient foods and foods that contain fewer calories from fat, the need for more efficient methods to extract oil reserves, and the need for improved drug-delivery systems. Biopolymers will play a role in these areas through their use in biodegradable plastics, food additives (including lipid analogues), enhanced oil-recovery chemicals, tissue engineering, and drug-delivery agents. Because biopolymers are "natural" products, they may require minimal regulatory review to receive product use approval. This fact makes biopolymers more attractive than similar synthetics, especially with rising consumer demands for all-natural products. Because biopolymers are biodegradable and derive from renewable resources, they are strong candidates for many industrial applications. However, biopolymers must compete with existing petroleum-derived products, particularly in price. Bioplastics cost approximately twice as much to produce per pound of resin as traditional plastics do. However, bioplastic manufacturers are beginning to reduce production costs by increasing and improving on production capacity and processes. In turn, greater awareness of green issues is making consumers more willing to pay a premium for environmentally friendly goods, thereby encouraging manufacturers to use bioplastic resins, and rising oil prices have driven up the cost of traditional petroleum-based plastics and will continue to do so. All these factors make bioplastics increasingly competitive.

Government initiatives to move toward bio-based chemical and industrial processing will support the development of biopolymers. An emerging area in biopolymer research is the application of biopolymers in the synthesis of new materials. Biopolymers are playing a key role in nanotechnology and biomimetic materials synthesis. Biopolymers have unique physical and chemical properties that researchers are using to develop the framework from which molecular machines and manufacturing will develop. Novel architectures based on biopolymer structures, such as lipid tubules and protein lattices, may open highly specialized market opportunities for biopolymers.

The major beneficiary of biopolymers is the food-processing industry, although other industries—including cosmetics, pharmaceuticals, packaging, paper, and textiles—also benefit. Biopolymers mainly fill needs in specialty applications, so producers must target their products toward several niche markets. Of course, producers are also looking for commodity-type markets for biopolymers, but these markets have yet to materialize, in part because of the availability of cheaper synthetic polymers. However, advances in plant genetics and in fermentation and purification technologies—by-products of the biotechnology industry—and an abundance of cheap natural feedstocks could eventually play a role in shifting the balance more toward the use of biopolymers and away from the use of synthetic petroleum-based polymers.

Biosensors
(Biosensori)

Biosensors represent a powerful technology development in analytical measurement. Biosensors have the ability to measure the presence, absence, or concentration of specific organic or inorganic substances and to do so accurately, with rapid response time, and with high levels of specificity. Their perceived advantages over existing technologies include the ability to monitor broad or narrow spectra of analytes in real time and to allow decentralized analyte testing at the level of singlemolecule interactions. Their perceived weaknesses include the instability of the biological molecules outside their natural environment, which results in a restricted shelf life and intensive research and development requirements.

Biosensors find commercial application in the areas of health care, food-quality control, pharmaceuticals, and environmental monitoring and greatest use in health care—especially in patient monitoring. A common requirement of all these applications is on-site analysis, preferably on a real-time basis. The resulting benefits of closer monitoring range from a more efficient industrial productions process to better-informed legislation on safety standards and population exposure to chemical and biological hazards. However, the market demand for biosensors in nonhealth applications will accelerate only when cheap and reliable biosensor technologies become available. The apparent opportunities in biosensor commercialization have led to interest by many large electronic and life science companies. However, without the technical skills, the delivery channels, or a unique, differentiated, biosensor offering, players will have great difficulty entering the market. Given the cost and complexity of biosensor development, a model of strategic cooperation is finding wide adoption.

Bottlenecks in the technical development of biosensors include the difficulty of fabricating devices in bulk and the single- or restricted multiple-use nature of most biosensors currently available (leading to the need continuously to repurchase device components as well as consumables). In addition, the combination of electronic and biological components in a working device is difficult and expensive to achieve and requires significant cross-discipline research. The high cost of biosensor development reduces the potential for biosensor use in low-cost applications. Because several competing technologies to biosensors exist (including dipstick tests and such laboratory techniques as spectrophotometry), the commercial success of biosensors hinges on their use in applications where they have a unique performance advantage such as simplicity of use, greater sensitivity, faster response time, or the ability to monitor an analyte continuously. Even in the largest markets (such as glucose monitoring) that biosensors can access, competition on price or technology alone is unlikely to form the basis of a successful strategy.

Connected Cars
(Automobili intelligenti)

Carmakers, electronics makers, wireless-service provides, and other industries are adapting to a new competitive landscape in which electronics increasingly defines the driving experience. Telematics—roughly, wireless communications for vehicles—helps drivers and passengers to be efficient, safe, entertained, informed, and connected to other people. Connected-car technologies also include onboard radars and other sensor systems that automatically respond to the environment (such as self-parking vehicles and smart cruise controls for stop-and-go traffic), as well as synergies between onboard electronics and portable devices (such as cell phones, portable navigation devices, enterprise-provided handhelds, movie and music players, handheld games, and storage devices) that drivers and passengers carry into the car. Drivers and passengers will rely on network technologies including cellular communications, digital broadcasts, short-range wireless links, wireless LANs, and WiMax. Wireless and portable devices enable new modes of in-vehicle entertainment, including pay radio, onboard entertainment systems that synchronize with home networks via Wi-Fi, and handheld devices that interact with displays that are embedded in the vehicle. Drivers stay up-to-date about local traffic, weather forecasts, sports results, financial data, and what's going on in the world. Electronics also help a mobile workforce to maintain productivity, whether in simply talking to clients while stuck in traffic or in generating contract documents. And in addition to car occupants, other entities will also use connections to vehicles. Car dealers, carmakers, insurance companies, law enforcers, and others will monitor repair and maintenance histories, use patterns, and other data.

Typical drivers worldwide have car radios and cell phones to keep them connected to the world, to colleagues, and to loved ones. Many cars also have windshield-mounted electronic-payment modules that help drivers maintain freeway speeds along toll roads. Both in-dash and portable navigation systems with onboard GPS are increasingly common, helping drivers find their way on unfamiliar streets. Telematics service providers use onboard GPS (and other means) to locate stolen vehicles and drivers in need of assistance and to notify emergency services when a collision occurs. Bluetooth car radios enable drivers and passengers to communicate hands-free via speakerphones or headsets without taking cell phones out of the pocket; legislation to improve safety is increasingly driving growth for such hands-free solutions. And portable music players can play back over a car's surround-sound system and accept commands from controls mounted on a steering wheel, so a driver doesn't have to take hands off the wheel. A special situation exists in Japan, where in-road monitoring infrastructure supports live, context-sensitive traffic reporting and optimized timing of traffic lights. But recently, users in several countries have increasingly begun to adopt in-dash and portable devices that send location and speed data to advanced traffic-report services, which provide very accurate real-time navigation assistance to help drivers avoid traffic jams—without relying on in-road infrastructure.

Continuing progress in telematics research and development promises to deliver new benefits. Future car-to-car communications could warn drivers of upcoming stopped traffic or a slippery road. Portable broadband services could enable drivers and passengers to enjoy all the entertainment and productivity benefits of the Internet while in motion.

Future vehicles may have their own Internet address, allowing a parent to locate a wayward teenage driver or allowing a commercial fleet manager to check fluid levels and other diagnostics for a particular truck. Smart signs and other in-road infrastructure could combine with head-up displays to let drivers see through fog and around corners and handle other low-visibility conditions. Using such infrastructure, car-navigation systems may interpret complex signs and simply tell drivers "it's legal to park here for 35 minutes." Smart signs might also cause a navigation system to issue a warning to "change lanes now!"—say, if a driver's lane of travel is about to become a rush-hour carpool lane. Also, future wireless-enabled diagnostic systems could give carmakers a way to detect trouble before it happens and perhaps even to solve problems before they occur by automatically updating a car's software. And when cars do need repair, a customer-service technician may be able to use a wireless network to troubleshoot the car as the car drives into the shop and have an estimate and work order prepared and ready for signature as the customer walks up to the desk. Some of these ideas are more likely than others to become everyday realities. Carmakers' attempts to embed communication capability into cars has often led to disappointing market results. Short design cycles in the wireless industry, in combination with long design cycles in the automotive industry, mean that wireless equipment embedded into cars is often obsolete after a year or two of service. Cultures and national agendas produce solutions that differ greatly from one nation to the next, interfering with the development of global economies of scale for factory-installed in-dash solutions. As a result, carmakers are increasingly interested in ways for cars to use the communication capabilities of the diverse portable devices that drivers and passengers carry everywhere. Drivers need plug-and-play solutions that connect different brands of cars, in-dash electronics, and portable electronics. Improved interoperability will be important to market development. And interoperability is difficult, given competitive rivalries among different brands of vehicles, electronics, and network services. But regardless of the business challenges, connected-car technologies are in fact enabling growth of new markets, and industries need to monitor how these developments are affecting how we drive and how we conduct business.

Connected Homes
(Case intelligenti)

Today's broadband-connected home networks help residential users enjoy entertainment, perform work, secure their homes, automate appliances, maintain health and fitness, conduct transactions, and connect people to one another. Tens of millions of households have already adopted broadband Internet, Wi-Fi, massively-multiplayer games, video on demand, VoIP, and IPTV services. But home-network technology is at a far more advanced state of development for some users—such as those who route video to multiple TV sets from home servers, use their cell phones to check images from home-security cameras, and control lights and climate via wall-mounted touch screens. Emerging applications include sensors that detect a user's location within the home, so that audio, video, and lighting follow the user. Home theaters also promise to become venues for immersive gaming, TV commerce, and virtual-reality fitness training. Many benefits become possible as a result of novel interconnections among broadband services, storage devices, displays, sensors, software, and other technology elements.

Although "smart-home" technology progressed slowly for decades, mass markets for home networking finally emerged in recent years. Wireless technology and standards help users address some of the key obstacles that they formerly faced—especially the difficulty of installing home networks and handling incompatibilities among multiple vendors. Wi-Fi and Internet protocols allow persons of intermediate technical ability to connect multiple PCs to a broadband Internet service. Advanced applications still require either professional installation or system integration by a household member who has suitable expertise and patience. But even the most advanced users and installers face decisions and challenges that reflect unresolved industry issues. Notably, demand clearly exists for housewide access to entertainment. But digital-rights management creates challenges for interconnecting HDTV sets in home networks. Similarly, worries about safety and the price of energy promise to drive demand for networked home security and energy-management applications. But customers still need solutions that simplify the job of interconnecting a PC-centric network with cell phones, security sensors, and climate controls.
Development of home-networking markets will affect household lifestyles, the business environment for industries that sell retail products and services, and suppliers to those industries. Future users will enjoy new content-delivery channels, an array of new telecommunications services, and a sense of command and control over household security and comfort. Manufacturers, service providers, retailers, and other organizations are creating complex multiparty business models, investing in large R&D programs, and devoting a good deal of marketing effort to home-network business development. Significantly, some home-networking companies are influenced by the cell-phone business, which offers low price of entry in exchange for recurring revenue. But nobody knows if the monthly and pay-as-you-go models will win the day against a simple cash-and-carry, plug-and-play approach to retailing. In any event, winning organizations will maintain a high level of awareness about what technologies households are prepared to accept and what specific benefits will become possible as technology progress translates into value.

Engineering Polymers
(Tecnopolimeri)

Engineering polymers—thermoplastic resins that retain their mechanical properties at elevated temperatures—provide lightweight strength, stiffness, toughness, and corrosion resistance in a variety of demanding applications. EPs also offer design flexibility, allowing the fabrication of flat, gently curved, and deeply contoured parts or intricate thin-walled components. Manufacturers and processors can tailor these materials to specific applications by combining the base resins with reinforcements and additives or by blending them with other polymers. As result, EPs have become an integral part of design engineers' toolkits, replacing steel, aluminum, glass, ceramics, and other conventional materials in many applications.

At present, most of the standard accessories of modern life—automobiles, coffee makers, cell phones, PDAs, and laptop computers, to name a few—incorporate EPs. EPs find widespread use in cars and trucks, dominating applications such as headlight lenses and air-intake manifolds. Electrical and electronic devices also make extensive use of EPs in applications ranging from connectors, sockets, and switches to housings for computers, printers, telephones, and MP3 players. Appliances, optical media (compact discs and DVDs), and power tools are other important uses for EPs.

Demand for these versatile materials will continue to grow as a result of new application development, steady growth in existing end uses, and ongoing substitution for conventional materials. Tomorrow's cars, homes, and workplaces—like today's—will rely on EPs' lightweight strength, durability, and design flexibility.

Flat-Panel Displays
(Monitor a schermo piatto)

For many years, information-system designers have sought a thin, flat, low-power device to display video and computer-generated images. Researchers have invented many flat-panel-display technologies, but only a handful—LCDs, plasma displays, organic light-emitting–diode displays, paperlike (or e-paper) displays, and field-emission displays—have achieved commercial viability. Flat-panel technology is a fundamental part of mainstream telecommunication, computing, and home-entertainment products.

Opportunities to use flat-panel display technology are widespread. In computer-equipment applications, FPDs—particularly LCDs—provide portability, space savings, and lower power consumption. Application of this technology to commercial and residential video is opening new avenues for training, entertainment, and communications. The technology lets instrument manufacturers incorporate more information-display capabilities into their products, making the equipment both more flexible and more user friendly. Vehicle designers can use FPDs to provide new forms of electronic information and entertainment for operators and passengers. Makers of consumer and office equipment can improve the interactivity of their products and gain the marketing benefits of a high-tech product-design style. FPDs open new opportunities for creative product design and enhanced functionality. Thus far, the desktop- and notebook-computer monitors segment has been the leading revenue generator for the overall FPD market. The displays-for-mobile-handsets-and- other-handhelds (such as MP3 music players) segment has also been a strong performer and second in revenue generating behind computer monitors. From the present to the foreseeable near future, however, the large-area TVs segment is and will be the main market driver, in terms of both technology and revenue. Several factors lead to TV's rise to prominence as the focus of overall FPD market. These factors are FPD's relatively low market penetration and high consumer demand (as a result of overall price reduction for FPD panels, several industrial countries' push for digitization of TV signals, and large international sporting events) in the TV segment and FPD's high market penetration and eroding revenue base (as a result of an especially harsh price drop in the lower-end segments) in the segments for computer monitors and mobile and handheld displays.

Today, FPDs have gained mainstream acceptance. As the price of LCD technology continues to fall, consumers have decided that flat-panel technology is at last affordable. Yet manufacturers cannot sustain price decreases indefinitely, and how they react to this fact will set the tone for the general deployment of FPD technology. LCD technology is and will continue in the foreseeable future to be the dominant FPD technology, in terms of both volume and revenue. The increasing adoption of OLED displays by mobile-handset and handheld-device manufacturers will help to push technology development forward, leading to a large-area OLED display. In addition, the emergence of e-paper displays in applications such as electronic signage, smart cards, retail-counter tags, electronicdocument readers, and other paper replacements adds to the diversity and will be a boost for the overall FPD industry. These developments, along with complementary research into fundamental display electronics, will ensure that FPDs become an increasingly familiar and important part of people's business, entertainment, and daily lives.

Fuel Cells
(Celle a combustibile)

Fuel cells produce electricity with greater efficiency, less noise, and far less pollution than combustion technologies do because the cells convert chemical energy directly into electrical energy. Scientists expect the technology to be very reliable, keeping maintenance costs low. Fuel cells are modular, allowing construction of almost any size power plant and simple expansion of existing facilities. Fuel-cell efficiency is relatively high even at low load levels and in small systems. All fuel-cell types can operate on hydrogen. Internal or external fuel-processing systems are necessary to enable use of hydrocarbon fuels in most low-temperature fuel cells (direct-methanol fuel cells are one exception) or to enable use of complex hydrocarbon fuels in high-temperature fuel cells. In the very long term, fuel cells might play an important role in an energy system that relies heavily on carbon-free or carbon-neutral fuels and energy cycles.
Fuel cells have provided electric power for some orbiting space vehicles but are not yet economically competitive for widespread commercial terrestrial use because of high capital costs. Development of market-entry products for portable power, remote power, and small-scale distributed or on-site power generation is nearing completion. Some companies have already begun limited commercial sales of fuel-cell systems for stationary-power applications. Heavy investment by a few automobile manufacturers has spurred rapid growth in R&D for transportation applications and produced some impressive demonstration vehicles. Fuel-cell–powered portable electronic devices may enter the market in 2007.
Fuel cells have attracted wide interest not only for their potential environmental benefits but also for their potential to change traditional ways of doing business. For example, fuel cells may give natural-gas producers and distributors a way to become electricity providers. Traditional electric utilities may be able to avoid transmission and distribution costs by going to a distributed-generation model. Other companies may simply see new sources of competition. For example, battery producers and companies that provide remote or emergency power systems, such as diesel generators, may see competition from fuel cells. At the same time, fuel cells may enable new technologies. For example, fuel cells may offer a way to power next-generation systems for military applications in remote areas. Should fuel cells find wide use, they would represent a new market for materials suppliers, equipment manufacturers, and even companies with software for process simulation and control. Membrane manufacturers, catalyst companies, and suppliers of specialized components, such as power electronics, may all see new markets emerge for their products.

Knowledge-Management Tools
(Strumenti per la gestione della conoscenza)

Knowledge-management tools encompass the technologies and techniques of collaborative computing, content management, and resource discovery, as well as the soft issues of teamwork, cooperation, and group dynamics. Companies increasingly recognize knowledge management's potential to unlock corporate information resources—both implicit and explicit—as they seek to improve business practices and processes, deliver innovative products and services, and gain competitive advantage:
Large corporations need to coordinate 24-hour operations worldwide and to manage distributed knowledge throughout the enterprise. Ever-larger computerized data sets and knowledge bases present large organizations with opportunities to share a greater percentage of their knowledge and know-how, in real time, across extended physical distances.
As a result of these developments, executives are turning toward the often vast amounts of information that now sit underused in their corporate databases, such as marketing information, account details, stock information, and product-design files. Even more data are available in unstructured form—on servers and on workers' PCs. Use of this information is improving within departments, but corporatewide, relatively little dissemination, cross-referencing, or merging of information are taking place. Internet technologies provide the necessary connectivity and interoperability for such sharing, offering a low-cost, standardized, future-proof, backward-compatible network infrastructure: a so-called intranet. However, adoption of an intranet as a corporate communications conduit is still not enough. Companies must develop, integrate, and optimize internal information sources to realize their growth potential, tap external knowledge sources—including joint-venture partners, strategic alliances, government and university sources—to improve or expand their capabilities, and provide all participants in the value chain with a framework for understanding, participating in, and improving the company's operations and profit-growth potential.

Knowledge-management tools help companies enhance knowledge creation and encourage its proliferation throughout the enterprise. Philosophers suggest that knowledge is useless unless people share it: Knowledge-management tools enable the collection, coordination, and distribution of information and knowledge so that team members can collaborate effectively in pursuit of a common goal. Although some analysts dismiss the term knowledge management as hyperbole, the underpinning technologies that support corporate content, harnessed by intranet and extranet systems, are common in many organizations. Only through the creation of networks of knowledge—both within and between companies—can organizations remove barriers of distance and time between distributed groups, increase quality and productivity, and build competitiveness within the expanding global marketplace.

Membrane Separation
(Separazione a membrana)

Synthetic membranes constitute a growing market and are providing enhanced separation capabilities in a wide variety of industries. Companies have invested in developing membrane-separation processes to perform separations that other, more conventional separation processes—such as evaporation, distillation, or extraction—cannot. Such investments can result in the creation of new business opportunities as costs for membrane systems come down or as new membrane-separation techniques become technically feasible.

Membrane separation eliminates the thermal degradation and chemical changes that can occur in distillation or evaporation. For this reason, membrane separations are suitable for separating temperature-sensitive products. In addition, they are often less energy intensive than conventional separation processes are, and the separation systems are modular, allowing very easy scaleup of processes.

Eight major membrane-separation processes—microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis, electrodeionization, gas separation, and pervaporation—are in use in such application areas as water purification (drinking water, wastewater, and ultrapure water), chemical and food processing, biopharmaceutical manufacturing, drug delivery, drug discovery, bioseparations, and medical treatment.

New membranes will operate under a wider range of temperatures and chemical environments and will provide more selective separations than are now possible. Increased global concern for the environment, demand for clean water, and energy efficiency are likely to result in increased opportunities for membranes.

MEMS/Micromachining
(Micro-sistemi elettromeccanici)

Industry continuously strives to make products that are smaller and lighter, are lower cost, yet have increased functionality. Micromachining is the ability to make components and devices whose features measure in the tens to hundreds of microns and, in some cases, even submicrons. Microelectromechanical systems, or MEMS, are a class of devices or microsystems produced using micromachining technology. Initially, scientists borrowed lithography techniques for making two-dimensional integrated circuits from the electronics industry to micromachine simple threedimensional cavities and freestanding membranes and cantilevers for sensor applications. Not only are microsensors smaller than conventional sensors, a characteristic that allows more functions in the same space, but they can also respond more quickly and more accurately, because of the smaller distances in use. Moreover, producing them in large batches is inexpensive. The extension of lithography methods and development of new micromachining techniques have allowed the production of freely moving micromechanical parts.

The biggest current market for micromachining is in sensors, from solid-state pressure sensors to automotive accelerometers. Also, the manufacture of many components in existing instruments and office equipment—such as the tiny nozzles in ink-jet printer heads, slider components for hard-disk drives, and the tips for atomic-force microscopes—relies on micromachining techniques. Micromachining has enabled cell phones to incorporate multiple functions, and MEMS-based microphones are quickly replacing traditional microphones in cell phones.

Micromachining is producing fluidic channels for DNA chips, allowing massive parallelism for high-throughput screening techniques, and is reducing some analytical instruments to handheld size. In the longer term, micromachining will contribute to implantable drug-delivery systems and other biomedical devices; tiny mechanical parts may allow the emergence of microrobots that can perform work in very small spaces, including those in the human body.

Almost every industry will enjoy the benefits of micromachining, particularly the information technology, telecommunications, automotive, and health-care industries. The relatively low cost of microsensors—$1 to $20 each—will also allow manufacturers to use sensors in many more products than they can now including consumer-electronics products, home appliances, toys, and products for home health care. These sensors and other micromechanical devices will eventually have remote powering and connect to the Internet, allowing remote interrogation of industrial sensors, connection of home health-care devices to a physician's office, and remote control of in vitro biomedical devices. Some time after 2010, industry may have to contend with another revolution: molecular manufacturing, or nanotechnology.

Mobile Communications
(Comunicazioni mobili)

Cell phones and mobile services are simply part of the fabric of our lives in the developed world—and increasingly so in emerging economies. Mobile-communications technologies have already greatly transformed the way we work, play, and relate to each other. Yet the changes and disruptions are far from complete. The great majority of traffic on mobile networks today consists of person-to-person voice calls and text messages. In contrast, the Internet delivers a much broader range of entertainment, commerce, and productivity applications. In fact, worldwide mobile-data revenues are significantly smaller than mobile-voice revenues. In addition, 2G-style services such as texting, ringtones, and screen logos remain the dominant mobile-data applications today. Certainly, cell phones have rapidly penetrated the mass market, but the promise of mobile communications will not become reality until mobile devices become ubiquitous channels for just-in-time information access, work-anywhere productivity, find-anything shopping, multiplayer gaming, real-time advice for navigating roads and cities, and dramatically new forms of social relations.

People often use the word mobile to refer to typical cell-phone services, which allow users to remain connected wirelessly to a network even in motion at high speeds. Many mobile-data applications depend on such services, which are currently undergoing a transition from second-generation digital technologies to third-generation infrastructures and mobile devices. Much interest focuses on the competition among various 3G technologies. Companies are especially concerned with the progress of companies following the most popular roadmap (which typically centers on WCDMA technology), many of which compete against companies following alternative roadmaps, especially that advocated by Qualcomm (CDMA2000) and that advocated by the Chinese government (TD-SCDMA). But many mobile-data applications use (or will use) other kinds of technologies and services, including WiMax; wireless LANs; hotspots, hot zones, and metro-area Wi-Fi networks; personal-area networks that capitalize on technologies such as Bluetooth; portable game consoles from Nintendo, Nokia, and Sony that have short-range wireless multiplayer capability.

Now that we have experienced the initial waves of mobile-services developments, what do technology roadmaps have in store, and what new applications will emerge? Future portable broadband services (especially those enabled by WiMax) have the potential to provide service that is similar to broadband Internet service, but without wires, delivering voice (via voice over Internet protocol), text, Web applications, and even Internet-protocol television—all from a single service, and perhaps even from a single handheld device that serves all the functions of a handset, storage unit, server, and router. Handsets could then automatically interact with each other and with various portable and fixed devices, leading toward a practical, ubiquitous future infrastructure. In the meantime, wireline-phone companies and pay-TV services are also proposing other approaches to fixed-mobile convergence. Other efforts are under way to enable mobile devices and networks to use location capability to support emergency-service workers, help people navigate roads and cities, help tourists find information, and even automatically rate restaurants and attractions on the basis of how long people spend in a particular place. Just as the Internet enabled entirely new activities that young people take completely for granted (such as use of social-networking software and peer-to-peer file sharing), future mobile networks promise to enable new and disruptive applications, help us reach our transit destinations smoothly, keep us connected to the workplace, and deliver the latest entertainment. Moreover, mobile technology may enable a new form of multiuser, P2P social interaction that is as dramatically different from today's text messaging as text messaging was different from conventional telephony. Many more innovations are in the works—notably intelligent infrastructure that supports ever-higher data rates; improved money transactions, including mobile music and video purchases and P2P payments; RFID readers embedded into handsets that can scan an item and read its price, ingredients, user manual, warranty information, and recycling instructions; and improved speech recognition, including voice browsing and humanlike conversational interfaces.

Nanobiotechnology
(Nanobiotecnologia)

Nanobiotechnology is a subset of nanotechnology—an area encompassing research and technology developments involving structures with at least one characteristic dimension measured at length scales typically below 100 nanometers to create new materials, devices, and systems. As novel properties in materials become accessible at the nanoscale, nanotechnology's greatest promise will come in researchers' ability to exploit such properties to create materials and structures with novel or enhanced features and functions and to assemble these materials and substructures with other components into larger devices and systems. Through its convergence with biotechnology, nanotechnology opens up new avenues of scientific research, technology development, and business opportunity. In particular, the study and control of nanoscale phenomena and materials offer the biological sciences novel functionalities and improved performance in materials in established application areas such as medical diagnostics and drug treatments. In the longer term, biology offers nanotechnologists unprecedented opportunities to explore, learn from, and use functional nanostructures that are inherent in living organisms to inform the design and development of entirely new classes of techniques and devices that could result in disruptive change in established fields such as health care. This potential for new insights into biological processes and nature's ability for self-assembly generates great interest in the field of nanobiotechnology.

The immediate opportunity from the application of nanotechnology in the biomedical and pharmaceutical sciences involves the creation of materials and devices that interface with biology at the molecular scale with a high degree of specificity. Today, nanobiotechnology's greatest impact is in the development of bioanalytical research-technology platforms, such as nanoscale labels or tags to improve signal generation and detection in biological assays. Leading medical applications include the use of nanomaterial technologies as medical-device coatings and diagnostic contrast agents, sensing components in nanoscale diagnostics devices, and advanced drug-delivery systems. New enabling-material technologies are also finding their way into consumer personal-care products. Improved tools to characterize, control, and manipulate the structure and function of living matter at the nanoscale could also inspire biology-based approaches to technology development and fabrication. For example, in medicine, researchers hope to synthesize new molecules, direct the self-assembly of individual biomolecules, and create molecular-scale multifunctional tools for in vivo sensing, diagnostics, analysis, therapy design, and drug delivery. Nanobiotechnology opportunities also span food, cosmetics, energy, and electronics applications. For example, improved understanding of nature's processes could facilitate the development of molecular-scale bio-based fabrication approaches for industrial materials and electronics.

Nanobiotechnology's potential for new business opportunities has been a key driver of research activity and investor interest, but technical and market uncertainties will temper the pace of development and lengthen the time frame in which opportunities materialize and commercialization occurs. Furthermore, the functional benefits of nanotechnology—such as the ability for nanoparticles to enter cells, cross membranes, and traverse the blood-brain barrier—could be its undoing. Important in any commercialization effort will therefore be the development of an infrastructure to support the testing, approval, and sale of nanobiotechnology products. All organizations should at least consider the broader implications of nanobiotechnology in their research planning, try to identify new business opportunities unique to the nanoscale, and assess the potential for cross-linking with other technology areas to offer breakthrough solutions in various application areas. This Technology Map highlights the technology building blocks of nanobiotechnology research and applications, identifies the key parameters affecting the commercial development of nanobiotechnology and its products, and pinpoints the technology and market issues that companies should monitor to understand the direction and pace of development in the research and business environments.

Nanoelectronics (Nanoelettronica)

Nanoelectronics is a subset of nanotechnology—itself somewhat of a catchall term—that this Technology Map defines as the ability to manipulate matter on a scale of less than 100 nanometers to create structures with useful electronic properties (1 nanometer is one-billionth of a meter). Decreasing dimensions in electronic devices has a long history of delivering cost and performance improvements. As the scale decreases to the nano level, new often-enhanced material properties arise because of quantum-size effects, interface phenomena, and very high surface-to-volume ratios. However, the top-down manufacturing processes of the semiconductor industry are only one option for producing nanoscale devices. A variety of other process techniques exist, including production of nanoparticles and carbon nanotubes or far-future concepts of using molecular machines to assemble devices. Such processes can lead to materials with properties unknown in the macro world, and when scientists learn to adapt these fledgling technologies to the production environment, devices and systems with new levels of performance will result.

Nanotechnology is such a broad science that we can forget that commercialization has already begun. Nanoparticle antistatic and antireflection coatings are already available, and one-dimensional nanostructures in the form of quantum-well lasers first saw commercialization in the 1980s and are now widespread in DVD players and telecommunications equipment. The conventional integrated-circuit industry will soon achieve 100-nanometer feature sizes, though novel quantum-effect electronic devices are still very immature; initial commercialization is likely to be in memory devices. The first wave of commercial devices to harness novel nanoscale properties includes hybrid devices such as sensors that use nanoparticles as one element in the active region, ultrasensitive magnetic heads for disk-drive storage, and solar cells in which nanoparticles can separate light-induced electronic charge. The minute sizes of quasi–naturally occurring carbon nanotubes can provide the basis of new nanomemory and field-emission displays.

Nanoelectronics will have an impact on almost every industry, because electronics itself is ubiquitous. However, information-technology and consumer-electronics industries will feel most of the early impact through enhanced storage and display devices, with nanoelectronics having the potential to revolutionize portable devices and ubiquitous computing. New nanostructured solar cells could alter radically the economics of this form of renewable energy, and new ultrasensitive sensors could affect several sectors, including medicine, automobiles, and defense. Several wild cards exist in the longer term: Futurists envision a world in which nanotechnology creates minute machines that, working in parallel, create micro and macro devices. What then is the future of human labor and current industrialization? Molecular- and

DNA-computing concepts could put processing and memory building blocks beyond the limits imaginable today—and for all intents and purposes would make these building blocks both limitless and incredibly small. Consideration of the near-term potential of nanoelectronics requires a realistic assessment of this technology, given its considerable immaturity, the need for practical production techniques, media and industry hype about nanotechnology in general, and the existence of many incumbent and competing technologies.

Nanomaterials
(Nanomateriali)

This Technology Map assesses the commercial potential of nanomaterials of nonbiological origin whose structures—because of their nanoscale size—exhibit novel physical, chemical, and biological properties, phenomena, and processes that significantly improve on those of larger-scale structures. At nanoscale dimensions (0.1 to 100 nanometers), nanomaterials and structures that derive from nanomaterials can behave in ways that are not predictable from observing their behaviors at large scales. The most important behavioral changes do not derive from nanostructures' order-of-magnitude size reduction but from new phenomena that are intrinsic to or predominant in nanoscale, such as size confinement, predominance of interfacial phenomena, and quantum mechanics. Scientists' control of feature size will lead to enhanced material properties and device functions in ways that we currently do not foresee or even consider feasible. Dimensional reduction of structures leads to entities—such as carbon nanotubes, quantum dots, thin films, laser emitters, and resonance-tunneling transistors—with unique properties. Such new forms of materials and devices could launch a revolutionary age for science and technology if scientists can discover, understand, and fully use the underlying principles.

How far materials science is from realizing practical benefits from nanomaterials depends on the aspect of nanomaterials technology one considers. Nature applies nanotechnology daily to grow the multifunctional cells and tissues of plants and animals from single biological cell structures, which contain programmable sequences of molecules. Nanomaterials already exist in their natural form, and they already help run our daily economy—for example, when we use quantum-based lasers to read compact discs and compact videodiscs. But the real challenge for materials scientists is to synthesize nanomaterials and nano-related structures and devices in efficient and cheap ways. Some scientists believe that the real contribution of nanomaterials will come when nanotechnology allows development of the first "universal assembling molecular machine"—a programmable molecular machine or assembler that can scale up production at frenetic rates; others believe that this goal is unreachable. Various nanomaterials, such as carbon nanotubes and nanoparticles, are commercially available for the manufacture of specialty products such as antistatic compounds and transparent coatings. Early users of nanomaterials include the chemical and materials industry, the cosmetics industry, the paint industry, and the nanobiotechnology industry. The nanobiotechnology industry uses nanomaterials in a range of applications, including biosensors, diagnostic devices, drug-release systems, and tissue repair and regeneration. In addition, the consumer-products and electronics and computer industries, energy-device developers, and the automotive industry will make good use of nanomaterials. The regional markets most active in commercializing nanomaterials are Japan, North America, and European countries, including Germany, France, and the United Kingdom.

Nanomaterials technology is still in its infancy, but as the technology matures, it could launch an era of technological revolutions. In the near term, not only will nanomaterials refine the development of existing technologies, but also they will bring new emerging and disruptive technologies to the marketplace. Venture capitalists will see opportunities to invest in new start-ups, not all of which will prosper. In the long term, according to popular hype, nanomaterials may lead to a powerful and accelerated social revolution in which virtually all present industrial processes become obsolete, along with our contemporary concept of labor. The reality will be somewhat different, but without doubt, nanomaterials have an important role to play in nanotechnology and will over time have a strong impact on people's lives. Consumer goods could become plentiful, inexpensive, smart, and durable. The capabilities of medicine could make a quantum leap. However, the application of stringent regulations at an early stage of the development of nanomaterials technology is likely to slow or inhibit its commercial expansion in some areas, and the practicalities and costs of developments will be prohibitive. Close attention to feasible and practical aspects of the technology is essential to form a realistic view of the future of nanomaterials.

Novel Ceramic/Metallic Materials
(Materiali metallici/ceramici innovativi)

Novel ceramic and metallic materials offer many advantages over other materials in a variety of structural applications—particularly in the defense, transportation, energy, electronics, and process industries. This Technology Map covers a range of advanced ceramic and metallic materials, notably advanced structural ceramics, ceramic-matrix composites, metal-/intermetallic-matrix composites, and interpenetrating-phase composites. Although key differences exist, these materials overlap significantly in terms of processing technologies, materials properties, and applications. In general, the high strength, wear resistance, and low weight of these materials can contribute to increasingly efficient and resilient transportation and power-generation systems. In addition, the thermal and electrical properties of these materials offer users advantages in many applications. However, performance, processing, and cost issues continue to limit the commercial viability of these advanced monolithic and composite materials. Processing difficulties, and toughness issues resulting in poor reliability, meant that structural ceramic materials failed to live up to the initial promise of the 1980s. In addition, IMCs failed to live up to the initial hopes of researchers in the 1990s, and emerging materials such as IPCs have yet to find any clear market niches. Developments in areas as diverse as advanced property databases, computer modeling of materials, industry familiarity, and industry structures will all aid commercialization of such advanced materials.

Recent years have seen a reevaluation of ceramic materials, with a significant shift in opinion about the realistic market size and technical benefits of these materials. Structural ceramics are already established in applications—for example, wear components and filters—where engineers can design around these materials' intrinsic limitations. The ceramics industry has already experienced significant consolidation. Further technical advances are still highly possible, leading to tougher, more cost-effective, and more reliable ceramics that will increase the range of applications for these materials.

Following their initial development in the 1960s and 1970s, high-performance MMCs first found use in various high-tech aerospace and defense applications. The use of exotic MMCs in these applications continues. In addition, industry researchers have worked to optimize the properties of lower-cost MMCs—especially AMCs—for volume use in, for example, automotive parts and electronic packaging/components. Significant commercialization has already occurred in these applications, and some AMCs are now available for less than $5 per kilogram. Materials science represents a set of interlinked, constantly evolving, and maturing technologies. Developments in emerging technologies—for example, nanomaterials—promise new ceramic and metal-ceramic composite materials that overcome existing limitations. Many industries are also driving the development of new materials that perform both structural and functional roles. Novel ceramic and metallic materials remain important and promising candidates for many applications.

Optoelectronics/Photonics (Optoelettronica/Fotonica)

This Technology Map follows developments in technologies that enable the emission, detection, and harnessing or manipulation of light and in their applications and markets. The terms optoelectronics and photonics are often synonymous. This Technology Map focuses primarily on minute devices, which manufacturers often produce using semiconductor fabrication, such as diode lasers and photodetectors, optical amplifiers, switches, light-emitting diodes, and passive components that can route, combine, and split up light. These devices enable the storage and high-speed communication of information, and they could revolutionize the lighting business. Materials for optoelectronics include semiconductors, nonlinear crystals, nanoparticle materials, and optically active polymers.

The main demand for photonic components comes from makers of fiber-optic communications systems, optical storage systems, instrumentation, and lighting. Telecommunications systems continue to be the largest market, and demand is now increasing for use of optoelectronics and photonics in shorter-distance networks: metro networks, optical local-area networks, storage-area networks, and optical backplanes in computing. If developers can keep reducing component prices and improving integration and packaging, photonics could support communication between chips and even on the chip, as faster and faster speeds become necessary and as electronic interconnects reach their limitations. New, more powerful optical storage devices will also be possible as researchers produce lasers with shorter and shorter wavelengths. Moreover, the relatively recent advent of blue lasers and blue and white LEDs will have a substantial impact on displays and lighting. Last, lasers are finding more uses in industrial and medical applications; these segments have become some of the fastest growing in the recent past.

Optoelectronic and photonic components are part of the "black boxes" behind today's communications systems. Without them, the cost of communication would be much greater, and bandwidth bottlenecks would be much worse: Optoelectronics is truly a driver of the information age. Though optical interconnection competes with electrical wiring, many companies provide both types of interconnection. Similarly, although white LED lighting will soon be more energy efficient and cooler than any other illumination technology—and at comparable price a few years thereafter, mass adoptions of white LEDs as incandescent-bulb replacements will still hinge on nontechnical factors such as public education and awareness and establishment of proper sales channels. What is certain is that white LEDs will replace cold-cathode fluorescent lamps as the leading type of light source for liquid-crystal–display backlighting, and they will soon be the light source of choice for future automobiles.

Organic Electronics
(Elettronica organica)

Most materials that have electrical or electronic properties are metals or inorganic compounds such as copper, silver, gold, doped silicon, or indium tin oxide (tin-doped indium oxide). This Technology Map focuses on organic electronic materials: carbon-based chemicals and polymers that exhibit electrical conductivity, semiconductivity, electroluminescence, or photovoltaic properties. Examples of organic electronic materials include light-emitting small molecules and polymers, organic semiconductors, and conductive polymers.

Although organic electronic materials offer distinct performance advantages in many applications, much of the interest in these materials is due to a more mundane attribute: their potential for use in low-cost, high-volume manufacturing processes. Organic electronic materials may play a key role in reducing production costs for flat-panel televisions, flexible displays, RFID tags, and other electronic devices. In addition, these materials offer design flexibility because of their compatibility with flexible and rigid substrates.

This technology has the potential for widespread application and could lead to ubiquitous, inexpensive—even disposable—electronic devices. Industry players include both large, diversified powerhouses of the materials and consumer-electronics industries and start-ups that focus on a single technology application. Current commercial products include OLED displays, capacitors, electroluminescent backlights, and static-control products. Emerging end uses include solar cells, lighting, flexible displays (electronic paper), and RFID tags.

Pervasive Computing
(Sistemi elettronici pervasivi)

Pervasive computing is the use of information technology and networks to monitor and respond transparently to human needs and desires. An ideal pervasive-computing environment would monitor and recognize the needs and wants of the people in it and would then adjust all aspects of the environment to suit its occupants. In its simplest form, a pervasive-computing environment senses a limited number of variables and uses those variables to serve a basic human need. Strongly pervasive environments could significantly improve the quality of life for many people, especially those who, by virtue of their age or health, cannot modify their environments for their own needs. Should researchers achieve the goal of pervasive computing—and should technology enable networked computing environments that are always on, always available, unobtrusive, and self-adjusting to meet people's wants and needs—the way that people relate to their surroundings will undergo a seismic shift. Greater safety, comfort, and efficiency will produce a variety of dividends. Nonetheless, pervasive computing—like other significant technologies—may also alter human notions of privacy, safety, and perhaps even liberty.

Many obstacles impede progress in pervasive computing. Technology for many envisioned products and services simply does not yet exist. In other cases, available technology is too expensive to allow for reasonably priced commercial products. Another difficulty is lack of interoperability given that many of the goals of pervasive computing, require providers to network devices. Standards and standards bodies may provide a route toward improved interoperability. Open-source–software development might also offer a solution to some interoperability problems. In general, however, companies have been reluctant to embrace an open-source approach to their software and hardware development, seeing it as a competitive disadvantage. Despite the challenges of pervasive computing, the potential benefits of the technology guarantee continued development. Some mildly pervasive systems already exist for use in constrained environments, and further development of pervasive-computing systems will likely proceed in line with Maslow's hierarchy of human needs: Most early systems will address human survival, and more advanced systems will seek to address less essential needs. Predictably, the organizations with the greatest interest in early systems are military forces and other groups that regularly place their employees in hazardous situations. However, the systems that developers create for such applications may have little in common with future pervasive systems for industrial, health-care, or home use. As such, redundant technologies are likely to evolve separately and overlap. This development path will create opportunities to provide a great variety of software and hardware.

Pervasive computing and the technologies that enable pervasive computing will provide business opportunities for suppliers of a wide range of devices, networks, and services. Some of these opportunities already exist; others await invention and development. As pervasive computing becomes more common, the number of wearable, mobile, and embedded sensing and computing devices will increase substantially. Many of these devices will have human interfaces, and demands on networks will increase. These network requirements will create opportunities for infrastructure providers and systems integrators. Most or all of the businesses that supply devices or services to military forces, industries, governments, health-care providers, and consumers will have new opportunities for profit.

Photovoltaics
(Impianti fotovoltaici)

Photovoltaic cells convert light energy directly into electrical power for applications ranging from wristwatches and water pumps to homes and space vehicles. Manufacturers can produce cells of just a few square centimeters or combine modules into arrays of unlimited size. The cells are silent, produce no emissions, have no moving parts, feature very low operation and maintenance costs, and typically last for more than 25 years. PV systems offer reliable, economical power in areas in which grid power is not readily available. With sufficient cost reduction, grid-connected PV systems also could find a market for on-site, emissions-free renewable electricity production in urban areas. Thermophotovoltaics, an emerging branch of the PV field, eventually could offer high-density, sunlight-independent power, expanding PV use to new applications such as thermal heating, water pumping, and hot water for household needs.

PV products are economical and well established in remote-power applications in industrialized and developing nations. The next decade will see significant improvements in system cost and performance that will expand existing uses and open large new markets. The PV industry hopes that a combination of government subsidies, favorable utility and environmental regulations, consumer preference for "green" power, and new building-integrated PV products will provide sufficient sales volume to help lower costs for applications in which small, on-site, grid-connected systems begin to be commercially viable. Utility-scale grid-connected power production is a distant prospect because of the low cost of power from competing technologies. Establishment of an appropriate financing and business infrastructure, along with cost reductions, would multiply PV sales to the enormous potential market for household- and village-scale electric power in rural areas of developing nations.

Improved understanding of cell materials and production processes has enabled substantial improvements in the performance and production cost of PV cells. Several thin-film and organic PV technologies, which are just beginning or approaching commercial production, offer the possibility of very low PV costs in the future. Unit shipments could grow by a factor of ten each time that PV prices drop by 50%, creating tremendous opportunities for module producers, production-equipment vendors, silicon suppliers, and makers of balance-of-system equipment such as power inverters, charge controllers, batteries, and tracking systems. As thin-film–PV technologies become competitive in large-scale applications, opportunities will arise for large-area deposition systems and glass and stainless-steel substrates. Building-integrated PV products and low-cost residential-scale systems would be attractive to architects and utility companies serving clients who favor renewable energy. Rural utility companies can use PV power to serve small isolated loads. Builders of wireless communication networks will continue to find PV power ideal for running remote transmission units. PV systems can bring clean, quiet power to remote resorts, camping areas, and environmentally sensitive areas. Integrated PV modules can extend the operating time of battery-powered portable-electronic devices.

Polymer-Matrix Composites
(Compositi a matrice polimerica)

Polymer-matrix composites consist of glass, carbon, or other high-strength fibers in a thermoset or thermoplastic resin. The resulting materials are strong, stiff, and corrosion resistant. PMCs adopt flat, gently curved, or sharply sculpted contours with ease, providing manufacturers with design flexibility. In addition, composites offer the opportunity for parts consolidation and lower assembly costs.

Polymer-matrix composites provide a stiff, lightweight alternative to steel, aluminum, and traditional materials such as wood. Currently, composites find use in a broad range of applications. In the aerospace, automotive, rail, and bus sectors, their light weight leads to lower fuel consumption. Their resistance to corrosion enables their use in marine, construction, and infrastructure applications, including piping and storage tanks. Composites' lightweight strength and vibration-damping properties protect athletes from tennis elbow and allow fisherman to cast with increased accuracy. In addition, polymer-matrix composites are the materials of choice for wind-turbine blades.

Composites continue to make steady progress in new as well as established applications. In the aerospace industry, the current emphasis on fuel efficiency favors the use of PMCs instead of aluminum; in addition, a new class of aircraft—microjets—makes extensive use of lightweight composites. In the automotive industry, manufacturers are recognizing the advantages of weight reduction, parts consolidation, and design freedom that PMCs afford. In the energy sector, the growing use of wind energy has led to increased demand for PMC turbine blades. Despite lingering concerns about the materials' recyclability (an important factor in automotive markets), the outlook for PMCs is bright.

Portable Electronic Devices
(Dispositivi elettronici portatili)

Portable electronic devices are transforming people's relationships with technology. Some 2 billion people carry cell phones with them, typically during most waking hours. Cell phones have become platforms for more than just voice and text communications. They also deliver an increasingly broad set of benefits, presenting entertainment and information, enhancing productivity, executing transactions, and supporting personal logistics by means of location-based applications. Yet at the same time, markets for noncellular handheld devices are growing rapidly. Hundreds of millions of people use portable music players and portable games—apparently carrying these devices wherever they go. Digital cameras and camcorders are extremely popular (despite the fact that so many cell phones include a camera). Portable navigation systems are experiencing rapid market growth. Some people have experienced emerging e-book readers and handheld "ultramobile" PCs; such niche products promise improved price-performance ratios and mass-market adoption in coming years. And other niche products could experience growth, including wearable computers, smart remote controls, and application-specific enterprise handhelds such as bar-code readers. And like smart phones that deliver increasingly broad sets of applications, noncellular handheld devices are expanding their roles, with portable music players playing games, global-positioning receivers carrying portable games, portable navigation devices playing multimedia, and so on. Thus, at the same time that booming markets for smart phones are delivering increasing benefits, remarkable growth is occurring in markets for noncellular handheld platforms, whose scope of benefits is also expanding.

Users, manufacturers, service providers, and content providers want to know how markets and technologies will develop in the future. In fact, technologies affect markets, and markets affect the types of technologies that develop. Some people believe that the typical future user will rely on a single convergent, multifunctional cellular device that delivers almost any application that a person could want. Other people believe that the typical future user will take advantage of several specialized handheld devices. Probably, different kinds of customers will adopt different collections of portable devices. Outcomes depend on individual preferences, technology progress, competition, the value propositions that suppliers offer, and other factors. Stakeholders can gain insight and reduce uncertainty by monitoring advanced R&D activities as well as business models and application trends. Competition among major brands in portable electronics—including Apple, BlackBerry, Nokia, Microsoft, Motorola, Nintendo, Samsung, and Sony—drives technology developments and creates barriers to entry for other companies. Strategies of major mobile-services brands—including AT&T, China Telecom, NTT DoCoMo, Orange, SK Telecom, SprintNextel, T-Mobile, Telefonica, Telecom Italia, Verizon Wireless, and Vodafone, to name a few—strongly influence the selection of handsets that appear in retail outlets. The direction of progress depends on the way suppliers face key challenges, including inadequate batteries, awkward user interfaces, security vulnerabilities, high prices for cutting-edge gadgets, and performance that lags that of high-power electronics. Even regulatory developments have important effects on outcomes: The ways that governments assign spectrum, establish rules for consumer protection, and enforce intellectual-property rights affect technology developments such as network interfaces, operating systems, application-programmer interfaces, and digital-rights management. Although external forces influence technology evolution, stakeholders can never forget that technology-driven laboratory developments are the key enablers of innovation and that the devices we hold in our hands today were, not so long ago, engineering prototypes and R&D visions. These devices are the result of progress in key technologies such as antennas, batteries, communications protocols, displays, embedded systems, memory chips, radios, sensors, and software-development platforms.

Portable electronic devices will likely to continue disrupt business and social trends. Despite the relative maturity of cell-phone, portable-game, and other markets, ongoing developments drive the need to monitor potential disruptions and their implications for the future. Technology advances such as location capability, voice over Wi-Fi, mobile TV, embedded RFID readers, and 3-D graphics chips promise to expand the scope of applications for portable electronic devices. Growth in customer activities such as social networking, user-created content, business collaboration, massively multiplayer games, virtual worlds, and elearning promise to change the ways that people use portable electronic devices. Competitive developments—such as embedded Linux, Google's entry into cellular markets, Apple's entry into portable video, and the battle to establish market share among BlackBerry, Microsoft, Symbian, and other brands of software—promise to affect R&D priorities and change business rules for users and suppliers. And sooner or later, users may experience a number of more speculative developments—such as the emergence of wearable "life recorders" and personal black boxes, displays that roll up into a package the size of a pen or are embedded in eyeglasses, portable fuel cells that last for weeks without recharging, free-form spoken natural-language queries for information, and machine-vision software that recognizes people, places, and things and delivers annotated information about them. R&D planners, business developers, government organizations, and others need to prepare for the range of possible outcomes and their implications to set timely research agendas, select appropriate partners, and understand the type of future that may unfold as portable-electronics developments progress through the pipeline.

Portable Power
(Fonti d'energia portatili)

Despite battery technology's lack of glamour or excitement, it has maintained its position as the predominant power source in portable and handheld applications for several decades. But now a new generation of wireless devices and portable-entertainment products is making power demands that even the more advanced battery chemistries—NiMH and Li-ion—are finding difficult to meet. Reductions in operating voltage and low-power processors have done little to offset the problem as device designers continue to enhance their products with extra features and capabilities. In addition to coping with increased functionality—such as color displays, speech-recognition capability, embedded MP3 and video players, and cameras—batteries are also having to cope with significant increases in voice and data traffic, as location-based services, electronic banking, and Internet access increasingly become standard offerings in handheld devices. At an even smaller scale, the development of miniature remote-sensing and microelectromechanical systems is also creating a need for miniature energy sources that can power microsize devices independently or become an integral part of devices through the use of thin-film–fabrication technologies.

Batteries are currently the most common energy source for portable applications, although considerable research effort and funding are centering on alternative power solutions that will solve the portable energy needs of the future. This research is investigating the potential of a range of energy sources, including kinetic, solar, vibration, electrochemical, thermal, and biological technologies and spawning the development of new energy devices that include micro fuel cells, microengines, and biofuel cells. In addition to assessing how conventional batteries can remain competitive in powering future portable and miniature devices, this Technology Map discusses the commercial potential of alternative technologies.

If manufacturers overcome the barriers to commercialization, alternative portable energy sources will provide strong competition to conventional primary and secondary batteries in OEM and retail markets for powering consumer-electronics devices. And as manufacturers increasingly integrate power sources into devices at manufacture, markets for replacement batteries will also decline. At stake is a multibillion-dollar global market for portable power that offers explosive growth prospects as portable devices continue to take hold.

Renewable Energy Technologies
(Tecnologie delle energie rinnovabili)

Modern renewable energy technologies are becoming mainstream in many energy markets because they offer increasingly viable and sustainable alternatives to today's dominant fossil-fuel (coal, oil, and natural gas) and nuclear technologies. Scientists are making advances in a broad range of renewable technologies for power production, transport fuels, and heating and cooling. Renewable technologies draw on continuously replenished energy resources—including heat and light from the sun, wind, biomass, falling water, heat from inside the earth, and ocean energy. These resources are typically large and dispersed, and their energy is often convertible with little environmental impact, including low- and no-carbon emissions.

Although renewable energy technologies are small contributors to energy markets today, the sector is growing rapidly in response to a confluence of critical drivers. Drivers include strong growth in world energy demand—particularly in developing countries, environmental concerns about pollution and global warming, the desire to increase energy security and diversity, rising fossil-fuel prices, and technology advances that are improving the performance and lowering the costs of renewable energy systems. A large-scale move to renewable energy is not a certainty, even in a high-oil-price environment, but government policies worldwide are playing a vital role in helping to advance renewable technologies and lower market barriers. More than 70 countries now provide some type of renewable energy–promotion policy, and the policies in the most aggressive countries such as Germany have proved extremely successful. Some technologies, such as large-scale wind, biomass, geothermal, and small hydropower are increasingly competitive even without subsidies. In recognition of these developments, a growing number of large industrial companies, financial institutions, and venture-capital–funded start-ups are rushing to develop market opportunities for renewable energy technologies.

Global annual investment into renewable energy technologies reached a record $100 billion in 2006. Growth opportunities for renewable energy producers and distributors in both industrialized and developing countries depend on specific local conditions—the renewable energy resource base, government support and energy economics, market factors, and institutional constraints. Grid-connected solar photovoltaic technology is the fastest-growing energy technology worldwide, creating opportunities for materials, component, and system suppliers for both silicon and nonsilicon thin-film technologies. Prospects are also bright for wind-turbine manufacturers in a growing number of countries as costs drop and utility companies invest in huge wind parks to meet renewable energy requirements. Biofuels producers and their suppliers have considerable opportunities to expand in the United States, Brazil, Europe, China, and other countries that are encouraging the use of biofuels in transportation fuels. Geothermal heating and power markets are poised for major growth in many countries, and small hydropower applications have significant potential to meet future energy needs, especially in developing countries. Ocean-tidal and wave-energy technologies are just beginning to reach commercialization but have even greater long-term potential than hydropower and offshore wind power. All these technologies have the potential to offer clean new sources of energy, provide economic-development opportunities, and improve the standard of living for people in rural areas. As more countries embrace the idea of large-scale renewable energy technology use, however, stakeholders also need to recognize and assess the trade-offs—economic, environmental, and social— associated with each technology—trade-offs such as land-management issues.

RFID Technologies
(Tecnologie RFID)

Radio-frequency–identification technology is an automated data-capture technology that uses low-power radio waves to communicate between readers and tags or contactless cards. Tags can attach to items such as components, products, packaging, or bulk batches of products to provide access to additional information for, for example, manufacturing, supply-chain, and asset-tracking applications. Contactless cards find use in passports, smart cards, and badges for authorization, identification, and payment applications. The technology promises to capture information accurately and reliably. RFID technology, in contrast to bar-code technology, requires neither line of sight nor alignment between reader and tags. Moreover, RFID tags are sturdier than bar codes, enabling their use in adverse manufacturing conditions (such as hot or dirty environments). Some types of tags—rewritable tags—allow for changes of information directly on the tag, whereas write-once tags establish a reference point for finding information in databases.

A major driver of the technology is the need for real-time Internet-enabled information access. Though RFID has been available for quite some time, the technology is still at an early stage of development and commercialization. Early use of RFID has demonstrated benefits for supply-chain management and logistics, but evolving use of RFID technology faces a number of technical and institutional challenges. The technology's accuracy and reliability need to improve. Existing infrastructures are limited—with an insufficient number of readers and middleware connecting RFID-captured data to other software modules—in contrast to infrastructures for bar-code technology. Implementation of an infrastructure that enables seamless use of the technology across all supply-chain partners will come with staggering costs because of the necessary hardware and software. Costs of individual tags, which manufacturers will produce in the billions if the RFID market lives up to its promise, are still too high for ubiquitous tagging of individual items in most commercial product categories. Nonetheless, return-on-investment potential and compelling operational benefits will drive adoption of the technology.

Initiatives such as Wal-Mart's rollout, which started in 2005; Metro's introduction of RFID in November 2004; and the U.S. Department of Defense's initiatives to implement RFID technology have been major drivers of market adoption, and one cannot underestimate the impact of these rollouts. The current introduction of contactless passports constitutes another milestone.

RFID technology is on the verge of becoming a crucial market enabler for manufacturing, supply-chain, and logistics operations; tracking; and security and identification applications. Adoption of RFID technology in manufacturing, supply-chain management, and identification applications is only the first step. Once a sufficient infrastructure is in place—in response to ROI and security considerations—a wide variety of other commercial opportunities will emerge, much as products and services proliferated in the Internet arena. New products and services will emerge that use the RFID infrastructure as a base. Among the applications with potential for market success are products that combine RFID technology with sensors, RFID-enabled end-consumer products and services, and new types of payment systems for mobile commerce. As with the Internet, entrepreneurs are likely to discover many other potential RFID applications, and market optimists (and industry hype) envision a gold-rush mentality similar to the one that occurred during the dot-com period. In reality, RFID technology is already demonstrating benefits. Use of RFID provides opportunities for virtually every industry, offering extremely high potential for productivity gains and bottom-line results. But the technology still faces a number of challenges and obstacles that require resolution before the industry can realize the road to commercialization. Developers, users, and investors need to take a realistic look at remaining RFID-technology–related issues to avoid making strategic business mistakes.

Robotics
(Robotica)

Robotic systems perform physical manipulations loosely based on human abilities. The strict definition of robots requires that those manipulations be programmable, performable autonomously or by programmable teleoperation. The International Federation of Robotics classifies robots in two ways: manipulating industrial robots and others. According to the IFR, a manipulating industrial robot is an automatically controlled, reprogrammable, multipurpose, manipulative machine with three or more reprogrammable axes, which users may either fix in place or make mobile for industrial automation applications. In other than manufacturing industries, a robot is a machine that users can program to perform manipulative and in some cases locomotive tasks under automatic control. In manufacturing, robots improve quality and productivity by reducing process variance and lowering total production costs. In many applications, both manufacturing and nonmanufacturing, robots free humans from hazardous, noisy, strenuous tasks, or they operate where humans simply cannot.

More than 1 million industrial robots are in daily operation around the world (more than 40% in Japan), and the market for industrial robots has matured. In manufacturing, robots can be a core technology of flexible manufacturing or computer-integrated manufacturing. As computer processors increase in power and decrease in cost, robots will provide increasing flexibility and operate more autonomously than current robots. Such capabilities will broaden future robots' applications into such areas as medicine, personal assistance, construction, cooperating robotic teams, and many others that require sophisticated operation.

Manufacturing companies will continue to benefit from evolutionary developments in robotic systems and related technologies. Service-industry applications of robots are an emerging area, and service industries are likely to see further benefits from the technology within the next decade. Military applications will drive the development of many mobile robots. Personal robots are emerging, especially for applications such as floor cleaning. Questions remain about the range of applications for such robots: Homes have become increasingly mechanized, and robots may be an unnecessary addition to people's living environments. Researchers and large manufacturers continue to develop advanced personal robots, especially in Japan. Such robots may start to have significant impacts on people's lives in the next 15 to 20 years.

Smart Materials
(Materiali intelligenti)

Smart materials produce direct, inherent physical responses to signals such as temperature, voltage, pressure, magnetic fields, light, and so on. Though the mechanical behavior of an SM actuator often is unimpressive in isolation, the ability to use a very simple device to produce specific mechanical action in response to specific conditions or signals can dramatically improve the overall performance of a device. Designers can use SMs to simplify products, add features, improve performance, or increase reliability with relatively little mechanical complexity.

Most SM markets and technologies are young and remain largely unexplored (piezoelectric materials are a notable exception), with only a few simple, derivative products on the market. Fortunate combinations of technology and market conditions can bring explosive growth in commercial activity, however, as medical applications of shape-memory alloys have shown in recent years. Most SM technologies will slowly enter the market as suppliers and technologies mature and as users gain familiarity with the materials. Several SM technologies have just begun to enter or approach the market, and might find strong early sales in a few niches. Rapid advances in electronic control technology will continue to reduce the cost and increase the benefits of SM use. Existing SM applications are surprisingly numerous and diverse. Examples include simple piezoelectric speakers, card-eject mechanisms for laptop computers, tip positioners on scanning microscopes, self-expanding stents to hold coronary arteries open after angioplasty, a snow ski that actively damps harmful vibration frequencies, self-dimming automobile mirrors, medical imaging devices, autofocus motors for cameras, active noise control for electric transformers, and electronically controlled resistance units for home exercise equipment.

Development of SM fields will benefit companies that use SM components to add value to products and services, companies skilled in using SMs to design new products and services, and materials processors that add value to raw materials. The small volumes of SM consumption likely will have little impact on raw materials suppliers. Near-term returns on investments by SM suppliers generally will be modest, because most SM fields still are building infrastructure and knowledge bases for efficient and effective production, marketing, and use of SMs. The specialized knowledge necessary to produce SMs and to incorporate them effectively into products will slow the spread of SM use, but it also has led to high market valuations for companies developing products for high-value applications. Smart structures, which fully integrate structural and mechatronic components, represent the most refined use of SMs and might eventually enjoy very large SM markets. Only a very simple SM-based smart-structure product is in commercial use today. Other important areas of opportunity include applications in which designers desire performance improvements or new features but are unwilling to accept the compromises necessary to use conventional mechanisms and products (including nonmechanical devices) that must operate in a variety of conditions but have rigid designs optimized for a single operating point. Though improvements in SM performance would increase the range of possible applications, the major barriers to widespread SM use are users' lack of familiarity, the need for low-cost, robust production processes, and the need for improved design tools to enable nonexperts to use the materials with confidence.

Solid-State Microsensors
(Microsensori a stato solido)

Solid-state microsensors are miniaturized devices for measuring physical and chemical quantities such as pressure, acceleration, speed, and chemical concentration. The advanced photolithographic, etching, and deposition techniques in wide use in the silicon industry have led to a predominance of silicon-based solid-state microsensors; manufacturers can produce hundreds or thousands of these sensors on a single silicon wafer. However, the emergence of non-silicon-based micromachined solid-state sensors is creating niche but important opportunities. Solid-state microsensors are a technological breakthrough in a mature worldwide sensor and transducer industry. These compact, low-cost electronic devices are inherently compatible with microprocessor control systems, including those based on artificial-intelligence concepts like neural networks and fuzzy logic. OEMs and end users will use solid-state microsensors to add significant value to their products for minimal added cost.

The first uses of silicon solid-state microsensors were in high-cost aerospace and military applications. As prices have declined and fabrication technologies have evolved, silicon pressure sensors have penetrated automotive, industrial process-control, and medical applications. Silicon accelerometers are seeing similar market growth in automotive , consumer, and industrial uses, including air-bag actuation, ride control, scrolling text on handheld electronic devices, and vibration monitors for industrial machinery. Although less developed, chemical microsensors will eventually find use in applications ranging from in situ blood-monitoring devices to handheld units for field chemical analysis. Advanced chemical microsensors also await further development but are increasingly finding use in domestic alarms, portable analyzers, HVAC systems, combustion monitoring, and medical applications. A multitude of new markets and applications for solid-state microsensors will continue to emerge, as the price of sensors drops further and as the sensors acquire increased intelligence and networking capability. Advances in sensor packaging, design, and fabrication open new performance-sensitive applications for microsensor technology.

Solid-state microsensors will continue to displace conventional electromechanical sensors, particularly in high-volume markets. OEMs will use electronic microsensors to add functions and improve the reliability of their products with no cost or size penalties, especially in automotive and consumer electronics applications. Industrial end users will use microsensors in an expanding number of process-control and manufacturing applications, even incorporating these sensors into fabricated materials. The medical industry sees microsensors as a boon to the continuous and direct monitoring of critical patient variables such as blood pressure and blood chemistry; plus, they allow monitoring to take place in the home. The logical high-tech counterparts to sophisticated microprocessors, solid-state microsensors, will be essential components in future systems that sense, evaluate, and act intelligently in response to environmental stimuli.

User Interfaces
(Interfacce utenti)

User interfaces are the links between users and technologies. They mediate people's relationships with computers, cars, entertainment electronics, office automation, technology in public space, and—especially—handheld devices, whose small screens and buttons limit the set of possible applications. UIs even define people's relationships with technology, especially when elegant user interfaces inspire loyalty—as in the cases of Apple's iPod and TiVo's video recorders. Conversely, challenging UIs discourage technology growth when people have trouble using gadgets—as in the cases of navigating menus to configure a cell phone's Bluetooth connection and setting up remote access to files stored on a home PC. Business decision makers and their customers are increasingly interested in improving the quality of experience when using technology to communicate, be productive, and so on. Some businesses are interested in the promise of very advanced user interfaces such as gesture recognizers, virtual worlds such as Second Life, holographic projectors, and speech-recognition and -synthesis systems that support humanlike conversation quality. Other businesses aim to improve use of evolutionary technologies by taking advantage of state-of-the-art usability-engineering and design methodologies. Such practices rely on feedback from users, who become highly integrated into the design effort—or even cocreators of the final product. UIs—which people sometimes call human-machine interfaces, human-computer interfaces, and other names—first came into many people's awareness when graphical user interfaces emerged for computers (such as

Macintosh and Windows PCs) in the 1980s. GUIs made it possible for people without a computer-science background to take advantage of information technology. Good usability, attractive industrial design, and innovative user-experience engineering promise to enable further breakthroughs in market development for handheld devices, connected homes, connected cars, connected workplaces, and smart spaces in public venues such as cinemas, arcades, and mass-transit stations.

The discipline of user-interface engineering covers a wide array of activities, from basic research to practical Web-page

design. Developments entail core technologies—such as sensors, actuators, control surfaces, and display devices—as well as highly integrated systems such as cars, aircraft, consumer goods, public-information kiosks, and, of course, everything that an electronics store sells. Services, too, have user interfaces, often consisting of Web sites, call centers with interactive-voice-response and speech-recognition systems, interactive TV menus, and other digital innovations. Even a company's brand is sometimes associated with a distinctive and recognizable look and feel, as in the cases of Apple, Microsoft, and Sony. A number of advanced-user-interface technologies are on the horizon. The social environment of the Internet—which people sometimes call Web 2.0—may be evolving toward a shared virtual 3-D world along the lines of Second Life. Shared 3-D worlds are the most current instance of the promised ideal of virtual reality—which would accurately simulate the experience of being in an imaginary environment. True VR systems typically include body sensors and head-mounted displays or special rooms containing multiple high-definition displays that show images of an environment that responds to the user's movements. But users have been disappointed in the reality of uncomfortable goggles and gloves, in combination with less-than-realistic graphics and very high prices. Similarly, science-fiction stories often tell of holographic images projected into free space—but the real-world price and performance of stereoscopic displays and real-image projectors do not match the science-fiction fantasy. Some researchers now focus on improving performance and lowering the cost of near-eye displays and displays that convey a sense of three-dimensional parallax. However, in reality, technology remains a long way from satisfying the human desire to escape from our flawed world into a virtual world that is solely for our enjoyment.

Instead, developments like the iPod, TiVo, and the 3-D Web illustrate the importance of simply improving design practices to catch up with what technology already enables. Consider Google Maps, which popularized zoomable satellite images that contain annotated street names. Such context-sensitive annotated information—people sometimes call it augmented reality—also appears on some car navigation systems and could increasingly appear on cell phones and future near-eye displays. Users may also increase their use of zoomable interfaces—say, zooming in on an image that represents on-the-job workflow and zooming out to see all concurrent work-related projects in a matrix. With the rise in enthusiasm for virtual worlds, expect companies increasingly to implement 3-D user interfaces for 2-D displays on computers and home-theater products, taking advantage of users' familiarity with navigating video games and based on exploiting the economies of scale in 3-D chips and software. But user-interface innovations will not stop with 3-D images on a 2-D screen. R&D labs are busy developing stereoscopic displays and free-space holograms that may require years to arrive in homes but will find initial use in retail environments and other public venues that draw attention to consumer-product promotions and high-ticket items like cars. Labs are also working to enable near-eye displays built into eyeglasses to become practical and affordable. And advanced research aims to create speech interfaces that resemble holding a real conversation with a human. Meanwhile, expect increasing use of speech recognition in everyday applications like voice mail and improvements in natural-speech generation (synthesis or sample splicing). And above all, expect inventors to produce unexpected innovations, such as HyperSonic Sound, a directed-sound technology that reportedly creates the illusion of beaming a voice directly into a user's brain. Another example of radical innovation: the Pick and Drop user interface demonstrated by Sony, which lets users cause an image to be projected on a screen by using a stylus first to point at the image on a handheld device and then to "drop" it onto a screen, or move a file from one device to another by using the stylus to "pick it up" virtually from one device, and "drop it" onto another device.

Virtual Worlds
(Mondi Virtuali)

The growing popularity of virtual worlds—including Second Life, a visually rich, avatar-mediated three-dimensional virtual environment, and the massively multiplayer online game World of Warcraft—is fueling the development of new online platforms and technologies that could take the Internet to the next level, enabling new forms of socialization, communication, collaboration, and commerce. Like virtual-reality systems (until recently, the most common type of virtual environment), virtual worlds typically offer 3-D environments that users can "walk through" and explore. However, virtual worlds are unlikely to use virtual reality's immersive hardware (such as head-mounted displays) for the foreseeable future. Instead, virtual worlds rely on server-side software, Internet communications, and client software running on desktop computers, consoles, and (potentially) handheld devices. Typical features of virtual worlds include avatars, real-time interaction among a large number of users, 3-D environments, in-world social activities, and tools for users to create in-world objects. Some virtual worlds also support financial transactions, and Second Life in particular has seen some individuals make sizable profits through in-world commerce. Some virtual worlds are open, public, environments; others are closed, private, environments.

Although some virtual worlds are already in existence, these environments are only the first wave of virtual-worlds commercialization. Arguably, virtual worlds are where the World Wide Web was in the early 1990s, when most people did not fully grasp or anticipate what the business implications would be and when performance, lack of applications, and poor usability hampered mass-market adoption. Certainly, virtual worlds need to improve on these factors before they will be ready for prime time. Open-source virtual-worlds software, improved user interfaces, scalable platforms, and interoperability between worlds are just some of the factors that will affect virtual-worlds development. Today, most

media attention focuses on Second Life (as well as World of Warcraft), but in fact, a growing number of virtual worlds exist, including PlayStation Home, There, Qwaq, and Active Worlds. Most of today's virtual worlds are primarily entertainment oriented, but business and educational applications are growing. For example, IBM has more than 6000 employees active in Second Life and regularly uses the environment to conduct meetings and other collaborative activities. The New Media Consortium runs an extensive virtual campus in Second Life and hosts regular conferences, university classes, and other education and business events. In addition, many companies are interested in how they can participate in virtual worlds for marketing, training, and collaborative work.

Virtual worlds, like the World Wide Web before them, are likely to have an impact on a wide range of companies and organizations. Consumer companies will be able to market and trade goods and services in the new consumer marketplaces that virtual worlds create. Consumer companies will also be able to test prototypes of new products and services in virtual worlds before creating them in the real world. Large companies, government organizations, and educational institutions will have new, highly interactive, and media-rich platforms for collaborative work and learning. IT, communications, and media companies will be able to provide virtual-worlds content, software, hardware, and communications. In the long term, virtual worlds could create a wide variety of economic, technological, and social changes in society, just as the World Wide Web once did. Perhaps one or more new global multinationals will emerge, mobile phones will control open-source avatars that will travel through many virtual worlds, and some consumers will spend more money in virtual worlds than in the real world. In time, people may find it difficult to separate the real world and virtual worlds completely because, for example, objects created in virtual worlds are "printed" in rapid-prototyping machines, and avatars become photorealistic representations of their owners. Some people believe that virtual worlds will lead to a transition from a 2-D Web to the 3-D Web. Although the 2-D Web is likely too well established to disappear, virtual worlds could give rise to a whole new Internet application (or set of applications), on a scale similar to that of the World Wide Web and possibly with even greater economic, technological, and social impact.

Per maggiori informazioni sui servizi di Business Intelligence:

Alessandro Deltreppo
Servizio Formazione, Progettazione e Gestione Progetti
AREA Science Park
Padriciano 99, 34012 Trieste
Tel. 040.3755272 - Cell. 328.4674198
Fax 040.3755320

Fabrizio Rovatti
Servizio Trasferimento Tecnologico - Innovation Factory
AREA Science Park
Padriciano 99, 34012 Trieste
Tel. 040.3755118
Fax 040.3755118

area.international@area.trieste.it