Foreword

The Swedish Technology Foresight project deals with opportunities for building our future, rather than attempting to predict it. “Future” is a word that easily conjures up the image of a well-defined goal toward which we are all rushing. But the future is constantly changeable. Our own role and participation in it may be shaped in different ways.

Development is the product of a constant interplay between technology, people, economics and public institutions.

Technology creates opportunities, the wishes and demands of *people* generate development and markets, *economics* establishes limits – and creates opportunities. *Public institutions* are affected by all of this, but they also exercise control through legislation and infrastructures.

In this dynamic interplay we cannot plan the future, but we can certainly plan *for* the future.

Today the Steering Committee of the Swedish Technology Foresight project can present its final report. In our work with future-oriented issues, the process itself and the dedication of the participants have been at least as important as the written reports. These reports will now serve as valuable background material for all those who have a responsibility and an interest in future-oriented issues in their daily work.

Our Foresight work was mainly conducted in eight panels. Their deliberations and recommendations are presented in separate, freestanding panel reports.

In its own final report, the Steering Committee has chosen to bring together the driving forces, technological development fields and future rends that have permeated all the panel reports. Our description in the synthesis section of the project’s common themes also serves as an introduction to the stimulating and exciting consequence analyses in the panel reports.

The preconditions for creating a “foresighted society” in Sweden are good, especially in light of the historical evolution of Swedish technology and industry. But as the reports unambiguously show, a continued favorable trend will now require fresh thinking and major attitude changes.

This positive basic outlook assumes, however, that no currently unknown political or economic crises or disasters will occur and, not least importantly, that Sweden will not “shoot itself in the foot.” Faulty political/economic decisions, or a failure to make decisions, can destroy the best of preconditions in short order.

Our positive basic outlook must not draw attention away from a number of difficult issues. For example, the panels emphasize that the application of the new biology raises ethical issues and that the growing use of IT leads to questions concerning privacy and security. Other issues are related to the impact of demographic changes and regional mobility.

An open but not uncritical attitude toward change, based on continuous growth in knowledge gained through lifelong and enjoyable learning, is the path that the Technology Foresight project is recommending and hoping for in Sweden.

The Technology Foresight project is aimed at literally everyone in Sweden. It is my hope that our work will stimulate thoughts, discussions and actions, both in daily life and for major decisions.

Many people have involved themselves in Swedish Technology Foresight, and project participants have shown great dedication. The panel chairpersons have played an especially central role. My task as project Chairman has been very exciting and stimulating. The most important preconditions that have enabled us to complete this assignment successfully have been good teamwork in the Steering Committee and a skillful management team, headed by Program Manager Lennart Lübeck.

For all these contributions, I would like to express my sincere gratitude.

Arne Wittlöv
Chairman of the Steering Committee, Swedish Technology Foresight

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Given knowledge and a desire for change, Sweden can build the future and perform better in it. By focusing on fresh thinking, education, research and knowledge, we can make the necessary preparations to respond quickly to future changes, no matter what they may be.

As part of the Swedish Technology Foresight project, 130 of Sweden's leading engineers, researchers, social scientists and industrial leaders inventoried the opportunities for technology and for Sweden as we face the future. Their reports are packed with stimulating and exciting consequence analyses, which explain how the future may be influenced by what we now know – or think we know.

Above all, rapid advances in information technology (IT) and the new biology, but also increasing globalization, will steer developments during the coming decades. Because we live in an increasingly borderless society where information moves at lightning speed, the process – the way of thinking – will be far more important in steering developments than particular actions.

The world appears to be in the midst of a technological breakthrough of a kind that will affect our entire society, both behaviors and structures. Just as the art of book-printing, the steam engine and the harnessing of electricity changed our society, changes in IT and the new biology will create dramatic changes in a relatively short time.

This change is reflected and described on a daily basis by phrases like "the information society," "the knowledge society," "online," "nanotechnology," "the new biology," "life sciences" and "the new economy."

The Swedish Technology Foresight project shows that there is a firm basis for such descriptions. Several of the expert panels' analyses and trend projections are both plausible and socially momentous. More detailed forecasts will not be especially meaningful, however, because practically all fields of technology are characterized by very rapid change and constant surprising breakthroughs.

What will instead be decisive is our degree of preparedness and our willingness and ability to respond to rapid changes.

Given knowledge and a desire for change, Sweden can influence the future and perform better in it. Given knowledge, curiosity and a willingness to rethink our assumptions, we can quickly adapt to future conditions, no matter what they may be.

The Technology Foresight project emphasizes that Sweden must invest even more in expanding the knowledge society and the thinking that can give it the preparedness it needs to remain a leading industrialized nation. It will be necessary to invest in research, but Sweden needs to do much more than this.

Conclusions for the future

Swedish Technology Foresight's main conclusions revolve around three key concepts: attitudes, knowledge and infrastructures.

Attitudes

We cannot plan the future – but on the other hand it is necessary to plan *for* the future.

Attempts to plan the future may easily lead to large-scale but perhaps not always appropriate decisions, which future generations must pay dearly for. On the other hand, by preparing for a future that is uncertain and constantly changing, it is possible to build a society that can face this future with confidence.

Thus, in order not to be surprised by the future, an attitude change is needed, and not only among traditional wielders of power. Desire for change, curiosity and a desire to experiment must permeate the whole society, from day care centers and schools to universities and research institutions, from public administration to industries facing competition.

Too many Swedish institutions, organizations and companies are fundamentally conservative and disinclined to change. Behind this is often a natural caution and fear of the future. Given solid knowledge, this must be transformed into a willingness to take chances and courage to explore unknown paths.

"Dare not be certain – but know and experiment" might serve as a motto for much of the work of Swedish Technology Foresight. The better the knowledge we possess about current conditions, the less frightening an unknown future will be. And those who have more knowledge also dare to test alternative solutions.

The task of change is not always enjoyable, but preparedness for rapid changes and willingness to implement them is necessary in order to achieve positive social development. Desire for change is perhaps the most important single driving force for positive social development.

Attitude changes are not something that a few economic or political decisions can decree in a society. Change is a process that must occur both in schools and administrative bodies, both in boardrooms and government offices. A process that continues and evolves every day, decade after decade.

Knowledge

To accept these attitudes – and to build up the expertise needed for the future – not only requires the willingness but also the ability to change. This presupposes a number of far-reaching reforms in various segments of the educational system.

*Lifelong, enjoyable learning for everyon*e is the necessary foundation for preparedness to respond to change. To achieve this, much of today's education and research environment must be fundamentally rebuilt. Regardless of whether we are talking about universities with their roots in the Middle Ages or schools with traditions dating from the public compulsory schools of the 19th century, established thinking, accepted truths and old lessons must be reexamined.

The new concepts and techniques used by further education programs in the workplace, distance education (also international) together with and IT and the new media offer opportunities that must be developed.

In the higher education and research system, a sharper focusing of research resources is necessary if a country with limited resources is to continue its successful development. It is of crucial importance to the future that Sweden can build academic environments that allow unbiased exploration of knowledge, while cre-

ating and expanding powerful research environments.

In many ways, research in a number of fields is undergoing a paradigm shift. Research uses techniques that extend far beyond traditional institutional boundaries. It is often pursued in parallel, concurrent and interactive processes that demand high standards of communication and concentration of resources. The lone researcher working in his laboratory is becoming increasingly rare.

It is increasingly important for small countries, in particular, to focus their limited resources in those fields where they are already leaders.

In Sweden's case, this applies very much to the IT field, materials technology and the new biology, and especially to interdisciplinary research where these and other fields can meet without being hampered by traditional institutional boundaries or geographic distances.

In a number of these fields, Swedish research is a global leader. By focusing its resources more sharply, it can also remain so in the future.

This means that the higher education system, research institutions and public agencies must develop and support a multidisciplinary approach, where unexpected combinations of academic fields will have the opportunity to evolve and to receive funding.

Infrastructures

To enable knowledge and attitudes to evolve and be applied in an optimal way, society's various infrastructures must be well developed. This applies both to such physical structures as transportation, energy and IT networks and to more intangible structures.

The borderlessness that is opening in a number of fields makes it both possible and necessary for different parts of Sweden to develop in different ways. Human equality and solidarity do not have to imply that everyone should do the same things everywhere. All regions must be able to develop their own special expertise. A borderless society not only implies tearing down physical and legal barriers, but also opening mental barriers to allow people, organizations, educational institutions and companies to work globally and interactively.

Many of today's legal, administrative and tax regulations must be adapted to enable schools, universities, companies and organizations to invest what is necessary to build the knowledge capital of tomorrow. Borderlessness and IT developments in particular make new demands on regulations. This may be true of everything from copyright law to company law, from tax law to fundamental ethical rule systems related to such core issues as genetic and biological engineering and computer privacy.

Both the overall arguments in the Swedish Technology Foresight report and the more concrete proposals in the eight panel reports are radical and forward-looking, and thus difficult and time-consuming to implement. In a number of cases, they assume changes in the attitudes and approaches of researchers, companies, public agencies, politicians and the general public toward how our society should best utilize and improve its technological expertise.

Driving forces

The overall forces that, more strongly than many others, are driving the changes that Technology Foresight has identified can be summarized in two words: individualization and borderlessness. In strong interplay, these forces are pressing technological advances forward. These advances, in turn, are becoming strong driving forces that are creating preconditions for new changes.

Individualization will be apparent at many levels. More and more people will increasingly demand individual solutions, whether it concerns consuming goods and services, being employers or employees, pupils, students, patients or consumers of health services, or consuming information, culture and entertainment. A combination of technologies makes it possible to offer personally tailored medical dosages and individually designed study programs. The new opportunities offered by technology – combined with attitudes and values that characterize the younger generation in particular – are making possible and driving this trend.

Borderlessness will likewise be reflected on a number of levels. It may, for example, concern European integration, which is causing national borders to lose their significance while regional and cultural solidarity becomes more important. It may also refer to world trade, multinational corporations, global capital flows and "virtual" companies that arise as groupings of players in different countries to perform specific tasks.

But borderlessness is also about blurring the boundaries between work, education and leisure, or between the different phases of life. It may refer to the fact that people may choose to spend periods of their lives in foreign countries or take courses at foreign universities from their homes or workplaces in Sweden, or that new social networks arise.

In the cultural sphere, borderlessness is becoming more apparent in a growing number of countries. The new event and tourism industry is spreading its products freely over a growing proportion of the world via broadcast media, video and IT. Mosques and churches stand next door to sushi bars and McDonald's. Borderlessness may also describe the interplay between different fields of technology and knowledge, leading to entirely new applications.

There is no reason to believe that the pace of change will slow, quite the contrary. External pressure, in the form of greater international competition, will become stronger. The ongoing revolution in information technology shows no signs of stopping. Instead, its effects are spreading continuously like rings on water to new branches of technology and fields of activity. The result is far-reaching changes in the conditions governing the business sector, public sector operations and people's lives. A revolution similar to the one in the IT field also appears to be on its way in the new biology.

Perhaps more than ever before, dramatic changes are predicted in a number of different fields of technology, leading in turn to advances in completely different branches of technology. In this way, they may also have a major impact on the rest of society and influence people's lives.

2 Pioneering technologies

Among all the dramatic and pioneering new developments in human knowledge, three fields of technology will, in the judgment of the panels, be of especially great importance during the period in question. They are information technology, the new biology and materials technology. The first field is already busily influencing social change, while the second is making its breakthrough. The third, which is basically a classic field of technology, is still in the research stage in its new form.

IT

The supercomputer of the 1980s has become the personal computer of today and will become the pocket computer of tomorrow. These, in turn, will be completely outclassed by computers that will be sold as early as tomorrow. During the past three decades, the number of transistors on a single homogeneous silicon chip has doubled approximately every 18 months. Meanwhile the costs of manufacturing high-capacity microprocessors and semiconductor memories have fallen at almost the same pace.

Today it is impossible to predict the magnitude of the advances in information technology over the next twenty years. Symptomatically, the information and communications systems panel chose to limit its visions to 5–10 years. Perhaps in a 20-year perspective, various types of capacity will grow by a factor of 100, per-

IT and biology are growing together. IT is providing deeper knowledge, which yields more and better medicines. Using IT and nanotechnology (atomcraft), computer chips can be built into the body, for example to create mind-controlled prostheses.

haps by a factor of 10,000. The difference is sizable, but its consequences are difficult to grasp even in general terms.

To assess its long-term impact on other branches of technology and on society at large, however, we should imagine a future in which computer power and storage and transmission capacity are, in practice, unlimited. Computer power will be increasingly taken for granted and will blend into its surroundings. More and more products will contain processors and be perceived as "intelligent," albeit at a very low level. Many products will also be able to communicate wirelessly with each other. Digital assistants will help us perform numerous routine tasks, perhaps especially searching for and sorting information.

Increasingly powerful and cheaper microprocessors have, in turn, speeded the development of telecommunications, where laser technology also plays a large role. Here, too, explosive growth is underway. It is impossible to say how long it will continue at an undiminished or even accelerated pace. But keep in mind that the Internet already reaches more than half of Sweden's households and that its traffic volume doubles every hundred days. Ten years ago, the Internet was hardly known outside specialist circles in Sweden.

Today wireless telephony, combined with simple text messages, has made a broad-based breakthrough. Many of today's capacity barriers will soon be but a memory. In the near future, figuratively speaking, everybody in the industrialized world will be sitting in the next room. Today it is difficult to foresee what consequences this will have in the business sector, the cultural sphere and for our personal experiences. It may mean a way to break the isolation of many people living in involuntary solitude, for example the disabled, sick and old, or it could make home health care possible to a greater extent.

The panels single out how important it is that in the future, using information technology, we will be able to simulate processes and systems to a far greater extent than before. This may include everything from the characteristics of new synthetic materials or biological processes at molecular level to global climatic or economic models. The computer will become an increasingly important tool in an open, experiment-minded society.

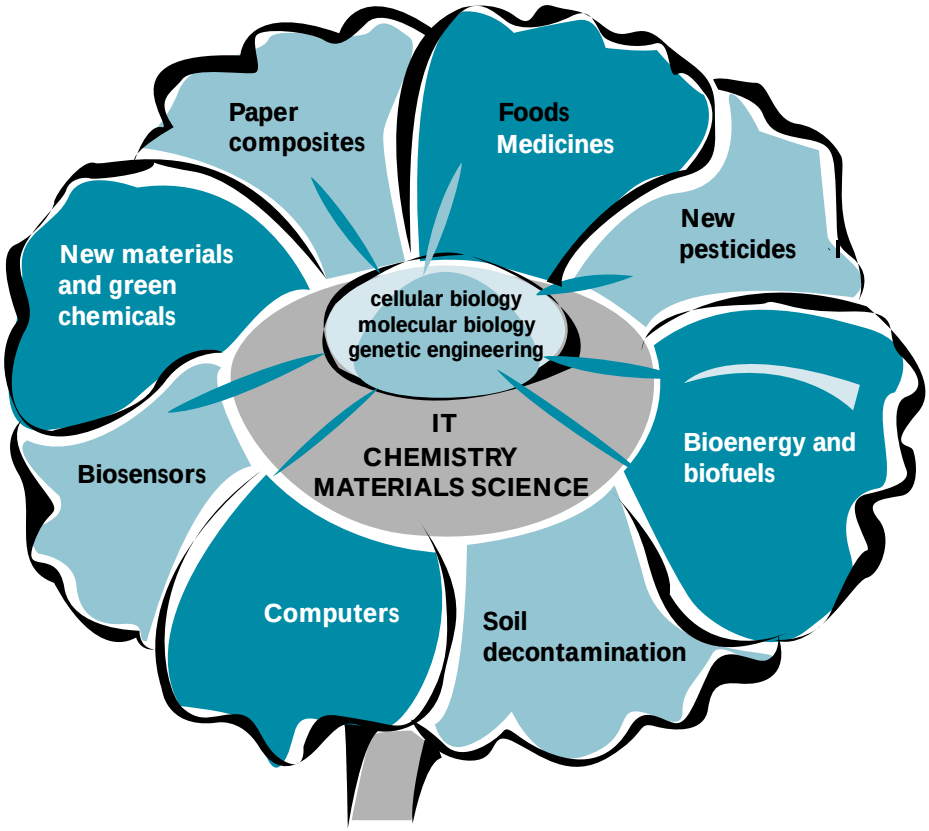
The new biology

Similarly, today our society is poised for dramatic advances in molecular biology and biotechnology. Soon the human genome will be completely mapped. After that, extremely large-scale research will try to ascertain and understand in detail how the genetic code affects physiological processes. Within a few years, technology will yield medically relevant findings that may open the way for new drugs and treatment methods over the next 10-20 years. Research will spell out various health risks with greater clarity and open opportunities to develop "functional foods."

Also highly important will be the opportunities that an exact knowledge of genetic structures will open for plant and animal breeders. Genetic engineering will probably also enable us to cultivate plants or microorganisms that efficiently produce high levels of desired substances, such as fuels (for example hydrogen), plastic raw materials and surface coatings. In this way, living organisms can function as chemical factories.

Information technology is a precondition for advances in biology, and major new opportunities will emerge in the borderlands between the two fields. For example, IT can simulate the biological processes and characteristics of various proteins and enzymes. This will make it possible to replace experiments and perform low-cost trials that could otherwise not be conducted.

Bioinformatics, developed precisely to make it possible to process large quantities



Knowledge explosion! A combination of IT, genetic engineering, chemistry and materials technology has created a knowledge explosion in molecular biology, which will dramatically affect numerous other fields.

of genetic information, is becoming an increasingly important tool for the pharmaceutical industry in the development of new drugs.

The opposite – that biological knowledge will make it possible to identify new applications for information technology – is also true. Sensors containing a biological component, known as biosensors, will enable researchers to discover and measure levels of many chemicals, odors etc. In medicine, it will be possible to use miniaturized sensors in a number of applications.

There is major potential in electronics, among other things because electronic components made of biological building blocks (“bioelectronics”) can be made very small. Our knowledge of molecular biology shows that it is possible to store very large quantities of information in proteins and to control cell processes.

Materials technology

Portions of materials technology have major potential to trigger advances in other fields. So far the primary focus has been on examining the characteristics of materials and how various processes affect them. Aided by an in-depth understanding of the structure of materials at the atomic/molecular level, we now see opportunities to actively design materials with desired characteristics.

Nanotechnology – atomcraft – is a breakthrough field in which researchers are now trying to handle materials at the atomic level. This may yield completely new materials with new characteristics and functions.

Using natural photosynthesis as a model, researchers today believe it is possible to achieve artificial photosynthesis by means of advanced material synthesis at molecular level. One objective of this development work is to be able to produce hydrogen gas with the aid of sunlight.

Medical technology is a field in which advances in information technology, biosciences and materials technology can together create completely new opportunities. Semiconductor surfaces, custom-made at molecular level using micro- and nanotechnology, may come into use as bioimplants. In the future, an implanted computer chip may reinforce nerve signals in order to end certain forms of paralysis or make effective prostheses possible. Even today, certain deaf people can regain their hearing, and experiments are underway to wire artificial "eyes" directly to the vision center of the brain.

Another promising research field that combines materials technology with information technology is "intelligent materials." By building microprocessors into materials and products, new functions are possible, for example process control, inspections and security. Sensor technology, an important element of this work, can help create resource-efficient, durable products such as low-emission engines and "intelligent" transport and logistics systems.

3 Future trends

All development occurs in an interplay between technology, people, public institutions and the economy.

Technology creates opportunities, while the wishes and demands of *people* generate development and markets. *Public institutions* are affected but also govern through legislation and infrastructures. *Economics* establishes limits – or creates opportunities. All this makes it difficult to single out what drives development and what results from it. For example, globalization is driving development in a number of respects, while technological advances and people's attitudes are helping to create a future society that is even more globalized than today's. In other words, globalization is both a driving force and a result.

The panel reports describe driving forces, current trends and expected developments. They also discuss the consequences of these developments for people, public institutions and the business sector. In many ways, their descriptions concur and draw similar conclusions. This section will examine some common features of the panel reports.

Outside pressures

Sweden is a small country that has extensive contacts with the rest of the world. We face keen competition in goods and services. Travel, the media, the cultural sphere and immigration are all sources of new impressions and ideas, and we are affected by international lifestyles and new fashions. This is something that all the panels single out. What is happening in the world around us affects our consumption and our way of living to a greater extent than before.

Sweden's membership in the European Union and other international agreements create pressure to harmonize the country's regulations and taxes with those of other countries. People and companies that move across borders will also put pressure on Swedish politicians to create conditions as favorable as those found in other countries.

Development both in the EU and globally are creating new, stronger competition between countries, which use various means to attract companies and individuals by offering them favorable conditions. As it becomes easier and easier for companies and people to change domicile, local and regional governments – but also nations – can and must resort to sophisticated marketing to attract companies and labor.

More open borders mean stiffer competition – and new opportunities

All the panels agree that the trend toward increasingly open borders will continue at a rapid pace, in interplay with technology and politics. Because of rapid global communications, information and capital can move with lightning speed. International trade will grow and competition will escalate as a result of continued deregulation in all fields. As national boundaries become blurrier, being part of a region or a trade bloc will instead become more important.

Companies are becoming more and more international. The structure of production systems and trade will undergo profound changes. Rapid physical transportation systems make it possible to move goods, people and expertise with ever-increasing efficiency.

The consequences for Sweden will be that we will face steadily greater competition – but also that we will gain access to a far bigger market for our products and services. An example is the rising prosperity of the Far East and other heavily populated parts of the world.

One disadvantage of more open borders is that Sweden's influence is diminishing as major Swedish corporations increasingly become internationally owned and controlled.

Open borders and elimination of trade barriers thus create both new markets for Swedish companies and new competitors inside and outside Sweden. Meanwhile protectionism and trade barriers continue in many places. Negotiations within the World Trade Organization are triggering resistance and protests. The major political, economic and religious tensions that still exist in the world may change conditions radically. It is difficult to foresee the political conditions that global resource gaps and appeals for fairness may lead to.

Some of the panels state that competitiveness and effectiveness require regions with sufficient resources in the form of infrastructure, business, research, education and culture. Stockholm/The Lake Mälaren Valley/Uppsala, Skåne (Sweden)/Copenhagen (Denmark) and Western Sweden are examples of regions that have the potential to become strong and competitive in this way.

Environmental issues drive society and business

For a long time, environmental and sustainability issues have occupied a central role in Swedish public discourse. As a result, for a number of years, Swedish industry and politics have been pacesetters in environmental adaptation and environmental policy decisions. Sweden's edge compared to other industrial countries is rapidly shrinking.

Life-cycle perspectives and efficient resource utilization have become increasingly central issues for Swedish society and business. As more and more people realize the need for closed ecocycles and greater sustainability in Sweden, the influence and choices of ordinary citizens are increasingly driving the introduction of environmentally friendly alternatives, which are eliminating traditional ones.

Energy supply occupies a central role in the Swedish environmental and sustainability debate. For years, Sweden has had lively discussion of nuclear power. Bioenergy use today accounts for half of the country's district heat production. Meanwhile attitudes have not changed especially much when it comes to the transportation technologies that cause a large proportion of greenhouse gas emissions. The public sector has resorted to various control instruments and has invested in research, but has not succeeded in changing behavior patterns very much. Several panels also predict that travel will continue to increase.

For businesses, environmental interest and commitment means that both outside organizations and their own employees are increasing calling on companies to report their environmental performance and impacts throughout their product life cycles. Many companies have introduced environmental management and certification systems.

More and more products are designed for reuse and recycling of components or materials. To a growing extent, companies sell functions rather than products: transportation services instead of trucks, heating instead of furnaces, etc. This also improves opportunities for companies to optimize the total environmental

impact of their products over their life cycle.

Many panels point out that sustainability issues have been, and will continue to be, a strong driving force behind the development of new technology, new materials, new modes of transportation and new infrastructure. This creates a strong domestic market for environmentally related products and services, which in turn will generate good prospects for Sweden to develop new, internationally competitive products in this field.

Knowledge capital

Sweden's new opportunities are found in knowledge-intensive fields, whose common keywords are "increased value-added" and "increased elements of intelligence in products and services." The panels point out a number of fields in which Sweden already has an edge and, taking into account our preconditions, also has good potential to develop globally leading companies and industries.

Thus, for example, Sweden can further enhance its leading position in the Internet and mobile telecommunications industries. In the same way, Swedish knowledge related to man-machine communication is growing. Together with other IT, this may develop even more, including additional advanced applications in medical care (telemedicine) and education (distance instruction).

A global market and deregulation make it difficult for Sweden to compete in bulk production of basic commodities. Based on technical advanced, precision-oriented resource management, we can produce first-rate products with a high knowledge and service content.

Sweden's extensive knowledge base in biotechnology (life sciences) and the growing field of bioinformatics will create new potential for research and companies. One growing related field is what is internationally known as "smart foods," which involves composing foods in such a way that they have preventive or medical effects on humans.

Sweden also has good prospects to go much further by using new technology to add extra value to traditional Swedish specialties such as fiber and wood products, and by continuing its efforts to develop advanced materials.

Sensor technology is a key area for many applications and builds on existing systems know-how and experience in the development of systems products for different industries.

Intellectual capital is growing

The trend toward greater customer adaptation, more intelligent products and freer work structures will have many consequences for both the business sector and society in general. The number of employees who work in the service and knowledge-intensive sectors will continue to increase.

For companies, intellectual capital will be increasingly important. This capital consists of both a company's organization and work procedures and the growing knowledge and expertise of its employees. Physical capital – which in economic terms is usually called "value of material assets" and can be sold in the market – will be less important in relative terms.

New patterns of manufacturing, distribution and trade are emerging. The value of a product is no longer generated to the same extent by physical production. Its value instead derives from the creation of services, in the market, in encounters between customers and the product owner and through its brand name.

Even today, traditional engineering companies are increasingly being transformed into software companies. Subcontractors that manufacture simple products without a large knowledge content are finding it increasingly difficult to compete with manufacturers in low-cost countries that operate in the same market.

New working methods and living patterns

Major changes in working methods and living patterns, driven by globalization and advances in the IT field, are one image that the panel reports reflect in different ways. The opportunity for instant contact with the whole world, collaboration in networks and access to large quantities of information are examples of these changes.

Both technological development and the market's demands for faster returns on investment are forcing companies to rapidly change and restructure themselves. The trend toward a narrower business focus, divestment or closure of mechanical production, replacement of hardware by software, outsourcing and specialization will probably continue.

Work in hierarchical organizations is being replaced by freer working methods and collaboration across organizational and national boundaries. Work is increasingly being pursued in project form and in "virtual companies." These consist of more or less loosely associated, temporary networks of many small companies, organizations and individuals. Both companies and people will have an opportunity to work globally but live locally – to collaborate regardless of distance.

Production systems will also change. Many traditional companies will narrow their operations down to their core areas and brand names, while specialized companies handle development, manufacturing, final assembly and logistics. Sales over the Internet enable sellers and buyers to find each other, regardless of distance. Today's retailers will change radically, and new services will emerge. One example is intermediaries (advisors/brokers) which, either via the Internet or directly, can help customers to choose products or services from a large number of sources.

These new working methods will also mean freer living patterns with looser ties to family, hometown and nation. Contacts and travel will provide new experiences and influence our values. Many young people will be attracted by the range of jobs, education, culture and living environment that expansive regions and centers offer. It will be possible to seek jobs and education over the Net.

For Sweden, this will mean greater competition, not only for manufacturing companies but also for service businesses and highly trained professionals. It will lead to sharply increased demands for speed, flexibility and capacity for change. But it

will also bring about new opportunities for Swedish know-how in communications technology and IT applications, and the creation of cross-border alliances.

For individuals, access to international education and careers will create new opportunities for personal development.

Greater individualization – focus on the customer

The strongest driving force for all development is human behavior. But it is very difficult to predict changes of attitudes. In different ways, all the panels touch on values and attitudes and discuss, in various contexts, how these may change. Although attitudes change much more slowly than technology, today it is not possible to predict what the young people of the future will think, nor is it possible to predict what today's young people will think when they are middle-aged.

The panels predict that today's trend toward greater *individualization* will continue. In the future, people will continue to acquire new values due to greater travel, increasingly global media, a general broadening of the range of media, international educational exchange and increased immigration. General prosperity and an ever-growing range of goods and services will allow an increase in consumption and greater freedom for the individual to choose how to spend money. Education and public services will become increasingly privatized and there will be greater freedom of choice. In the housing market, today's shift toward a greater degree of private ownership will continue.

Because of these trends, individuals are gaining greater influence and power through their choices of products, services and public amenities. This is a result of greater access to information, internationalization of markets, keener competition and growing individualization.

New products and services are being developed in an interplay between people, the market and public institutions. Competition leads to the introduction of increasingly intelligent products that include a greater element of services, making it more difficult to distinguish the product from the service. Although cars are becoming more technically advanced, the proportion of services delivered during their service life is increasing. A car company sells not only a car but also comfort, communication and navigation systems, computerized performance control and automated servicing and recycling. Being able to offer customers freedom of choice is an increasingly important competitive factor. Because the customer meanwhile has access to more information and a larger geographic market than previously, competition is stiffer.

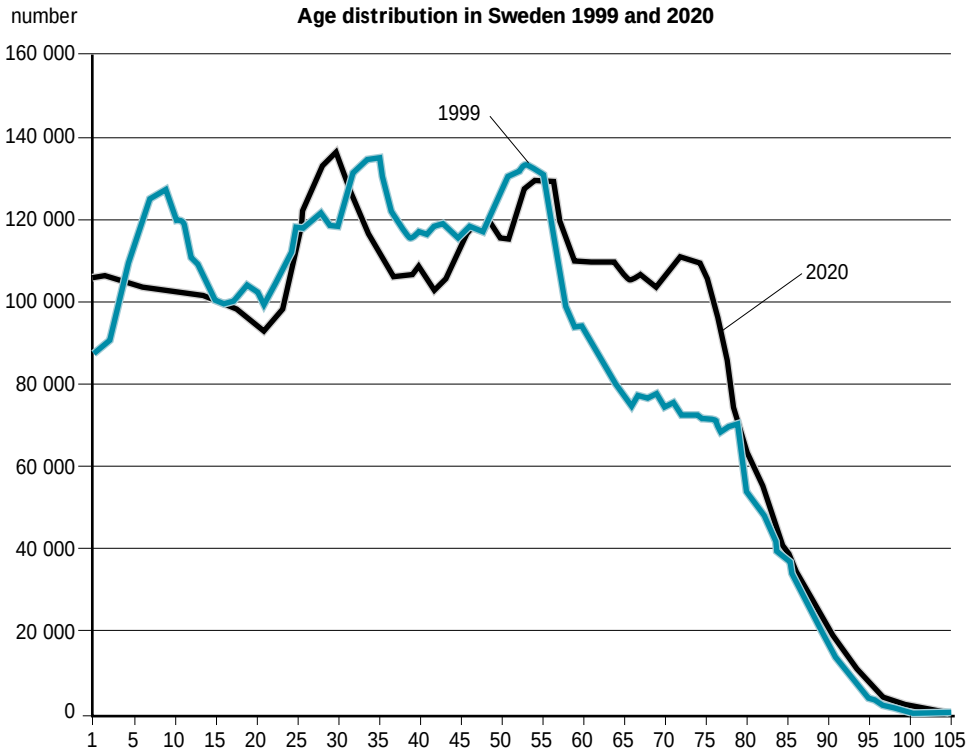
New Internet-based brokerage firms and companies that offer purchasing assistance and auctions provide customers with further information about their choices. Greater freedom of choice is being generated by better technology and the fact that companies see competitive advantages in this. Meanwhile it is also driven by customer demand for individualized products. Obviously the stronger role of the individual applies not only to the choice of products, but also services, health care and social services, both private and public.

More, older, healthier

In Sweden, as in all industrialized countries, the proportion of older people in the population is growing very fast. More and more people are living longer and longer. With the help of diet, exercise and medical advances, they can stay healthier and more vigorous for longer. Meanwhile, Swedish birthrates are currently very low.

This demographic trend may lead to a labor shortage and difficult problems for the Swedish economy when a working-age population that is shrinking in relative terms must support and help a growing number of pensioners in their 80s or older.

More and more people will be older and healthier. The number of pensioners will grow rapidly in the next few years. This will create new challenges for Swedish society as a whole– not just for the health and social service systems.



Because of their improved state of health, the need for medical care will not increase as fast as the number of pensioners. On the other hand, a generation of more informed, healthier older people with greater financial clout will demand and buy more care, services and housing of higher quality. Improvements in medicine will also generate pressure on the pharmaceutical and health care system to live up to these demands.

The shrinking percentage of working-age people in the population may lead to a labor shortage, especially if jobs in the health care sector are no longer capable of attracting more employees. This problem may be greatest in regions of declining population where mainly old people stay behind. Another consequence of the changed age structure is that a smaller relative number of working-age people must sustain the costs of health care and social services and also pay for investments in new infrastructure.

The move into cities generates new needs

Geographic distances are becoming less and less important in our technologically advanced society. In spite of this, in the judgment of the panels there will be a continued flow of people from rural areas and small towns to Sweden's major cities. This will increase the pressure on expanding regions to grow more and will draw resources away from the regions that people leave behind.

In growth regions, especially Sweden's three largest urban areas, there is a need for major expansion of housing, roads, public transit, education at all levels, energy supply and health care. Competition between regions will require these growth regions to invest in offering people a broad range of education, culture, leisure pursuits, retail and services, good communications and a clean environment.

Environmental and health issues are important, especially when transportation systems are expanded. There is a need for low-emission vehicles, efficient "intermodel" transportation systems and efficient logistic systems.

Ethics and privacy

Technological development also increasingly requires difficult human decisions.

The new biology and the application of genetic engineering are leading to ethical issues and conflicts. The reports from panels 1 and 2 indicate that researchers are convinced that advances in the life sciences will lead to unforeseen opportunities in the health care, pharmaceutical and food processing sectors as well as in raw material-based industry. There is also great uncertainty concerning how people will respond to the risks and ethical issues associated with genetic engineering. These issues are very important, because they concern our view of life itself and of human beings. They are emotionally charged and are permeated with ethical and religious aspects.

Another problem area that several different panels mention is *security and privacy in computer systems and communications networks*. Almost unlimited transmission and storage capacity is creating excellent opportunities to gather information about individuals, for better or worse. How should privacy issues be handled in an open international environment? Will people react against open systems? Will openness triumph even in countries that, for political reasons, want to control their citizens? And what will happen in the struggle between established software and media companies and young rebels with their freewheeling attitude toward rights and commercial interests?

As more and more sectors of society are becoming increasingly dependent on information technology, society is becoming more vulnerable. More and more systems are IT-based and take for granted that the technology will always be available and working. What used to be an unremarkable and temporary problem, such as a severed cable or a short-term power outage, can now create severe problems for entire communities. This has created greater opportunities for those who wish to subject our society to threats and disruptions. Single irresponsible individuals or groups can more easily sabotage important functions in society. It remains unclear how public institutions and businesses should protect themselves against this.

The answers to these questions are important not only to us as individual citizens, but will also be of great importance to the business sector and for national growth.

How far should we go? Ethical issues are becoming more urgent as we learn to interpret the information found in genetic material and can thereby control more of the fundamental mechanisms of life.

4 The panels look at the future

The eight panel reports contain very extensive and varied material that portrays a number of conceivable future scenarios. The panel reports have tried in different ways to describe the possible impact that various technical developments have on society and people.

Their purpose is not to use these descriptions as a basis for trying to create a forecast of Sweden's development. Instead, they focus on important areas of change and single out a number of central issues.

Technology in the service of man

One concept that has permeated the work of the panels and the entire Swedish Technology Foresight project is "Technology in the service of man" – improving the quality of life. Technological development is obviously of crucial importance for economic growth and the competitiveness of companies, but new technology may also provide other important contributions to human well-being related to health, leisure, social activity etc.

Sweden should endeavor to use new technology to raise efficiency and improve operations of all kinds, regardless of whether they take place in the public or private sector. Key concepts here are good education and lifelong learning, among other things about new technology and the opportunities it creates.

Another key concept is the general stimulation of research and development concerning the interplay between man and machine. To ensure that the increased range of products and services will make life easier instead of more complicated, greater efforts and understanding are needed in this area. For example, better and friendlier "man-machine interaction" must be developed for communications between people and computers.

Technology in the service of humanity also means taking advantage of technology to directly improve people's quality of life. Two areas of application are especially important here: education and health care.

Swedish development of knowledge and tools for technology in the service of man is singled out by several of the panels as a central area for increased investments, to ensure that Sweden can offer better products and services both for its own domestic needs and for the world market.

A richer and freer life...

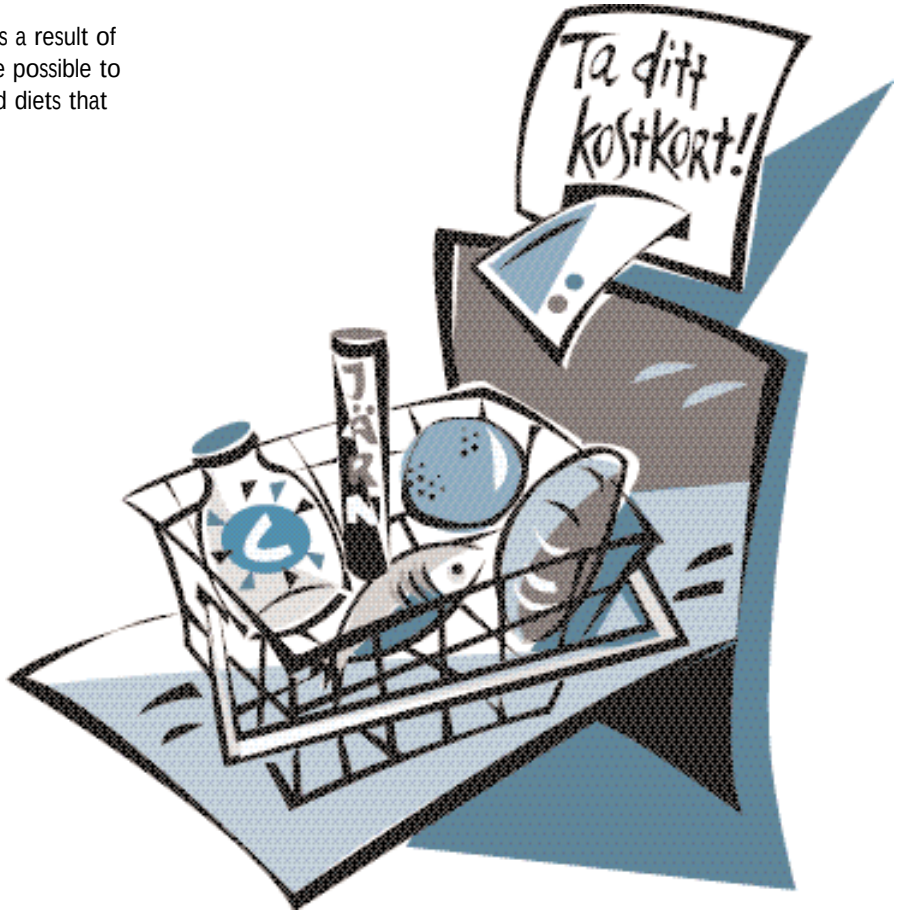
In looking ahead at the future, the panel reports present a predominantly positive picture of how the Swedes will live, reside and work.

"The city as a meeting place and arena" (3)* will offer cultural amenities and meeting places as well as interesting professions that allow people to work together. Intelligent buildings, e-commerce and new distribution methods, a wider range

* References to panel reports are placed in parentheses after the relevant text.

Proper diet prevents illnesses. As a result of effective gene mapping, it will be possible to compose individually customized diets that promote health.

The sign says: Take your diet card!



of services, "digital assistants" and convenient, safe payment systems will make daily life easier and reduce the need to run errands and stand in lines (5,7)

Freedom of choice will increase in many respects. There will be "individualized products" (4) and a wider range of housing alternatives (3). The range of leisure experiences (2, 7) as well as products made of new materials for games, sports and recreation will continue to increase (6). Innovative cuisine and "smart foods" (2) will provide nutritious and convenient high-quality eating, while preventing diseases and making us healthier. "Thinking and speaking packaging systems" will help us keep track of whether our food is fresh.

The element of services will increase (all panel reports), "intellectual capital" (4) will be better utilized, as will people's knowledge and ability to think. Work will become more flexible, and hierarchical organizations will be broken up. The availability of instant contact with the whole world will make it possible to "live locally but work globally" (4) and will increase people's freedom to choose when and how they want to work.. IT advances will open up major opportunities for "lifelong learning" adapted to the individual (8) and to personal development at work.

... but will there be any free time – and any security?

The panels not only present positive images, but also discuss many questions and risks related to future developments.

How will people cope with always being online and with the dissolution of boundaries between education, work and leisure? Will they be able to spend time with their families, meet friends, travel and engage in personal development (5, 7)?

Will there be any "free" time, when more and more work occurs at home and performance rather than work effort is what an employer is buying? Will individuals have a sense of constant, intensive competition, and will they feel insecure about time-limited projects and virtual companies? Will there be a trend toward more anorectic organizations, stress and burnout (4)?

Will many people drop out, and will the gaps between people grow wider?

A healthier life for everyone ...

The image of a healthier and better future life, including new devices to help the disabled, is discussed not only by panel 1 (Health, medicine and care) but also by other panels.

The biological revolution will create many new opportunities. Knowledge about the causes of many diseases will be revealed. New diagnostic methods aided by genetic engineering will make medical care more effective (1), including customized drugs adapted to the individual.

The boundary between food and medicine will become blurred. Alternative medicines and functional food (1, 2) will not only give us opportunities to choose a healthy diet in the traditional sense, but also to develop foods that help us become healthy.

IT will provide new opportunities on a number of levels: as a working tool for health care personnel, to provide information to patients, in devices to mitigate various disabilities and make life easier and richer for older people (1, 5). The "digital assistant" may be of particular importance to older or physically disabled people. "The intelligent bathroom" (5) can provide signals about a person's state of health and may be help home medical care patients – but also healthy people of working age.

New materials and IT will create the preconditions for improving various technical aids and prostheses. What the Swedes call "spare parts people" may have organs or prostheses made of new materials, but also implants cultivated from their own tissues (1, 6). It is not just a matter of devices to help the disabled, but also of various materials and products for everyday life and leisure that will enable people to "feel good their whole lives" (6).

IT will also give patients greater influence. Better knowledge about health care opportunities and available treatments will give people a better chance to have their wishes satisfied (1).

... but how do we deal with escalating medical care costs and the new ethical issues?

The increased availability of medical information and the broader range of health care and social services for medical patients, older people and the disabled will also increase our expectations and demands. Sick people of all ages will want to have the newest medicines and the best health care. When the numerous – and often financially strong – generation born in the 1940s retires, and as their knowledge of health care opportunities increases, they will want increasingly high-tech health care, new medicines and perhaps also "spare parts." Will the Swedish public sector be able to cope with these health care costs and the necessary investments? Will there be a widening gap between those who can articulate their wishes and those who cannot do so and who have no access to knowledge, information or financial resources of their own (1)?

Obviously, rising expectations are not the only thing that will put pressure on the public sector. The increased number of older people will mean more sick people and more individuals who cannot take care of themselves. Will there be enough

health care personnel, or will IT services and surveillance replace human contact? "Who will receive health care and at what price?" (6).

Many ethical issues need to be resolved, especially those related to how genetic engineering and information obtained using genetic engineering-based diagnostic methods will be used. Panel 1 raises several of these issues: Should knowledge of your genetic profile be reserved for you, or should others have access to it? Should there be mandatory disclosure concerning hereditary diseases and diseases for which there is not yet any treatment? Will technology affect people's views about birth control? Who actually owns our genes?

A good environment and good growth opportunities in successful regions and cities...

Major cities and growth regions will expand, and the move from rural areas and small towns will continue. People will be attracted by the range of jobs, meeting places, cultural amenities and social life in cities – although some will choose to live in the countryside and telecommute with the aid of new technology (3, 7).

The growing element of services in the economy will generate many jobs. Granted that communications technology provides great freedom to work independently of location, physical meetings, proximity and creative environments will still be necessary (3, 4, 5, 6, 7).

Medium-sized cities, too, can join forces to form competitive regions (3). Technology makes it possible to create network-based collaborative arrangements without the need for geographic proximity. Meanwhile, future rapid and environmentally friendly forms of transportation will shorten distances. Regions can also extend across national boundaries: the Öresund region of southern Sweden and eastern Denmark is a current example (2, 3, 4).

The movement to cities and demographic changes will lead to major challenges and changes in large cities. Downtown areas will increase their density of use, new urban cores will emerge in peripheral areas, and mass transit will have to be expanded. This means that not only traffic jams and congestion problems but also resource efficiency will also be a driving force. To keep up with the demand for housing, supply must be enlarged and the density of housing with access to mass transit must increase. Also needed will be new housing in general and residential developments for older people in particular (3).

... but will it be possible to continue living in other parts of Sweden? Can our major cities cope with competition and renewal?

However, the growth of major cities and the depopulation of rural areas may lead to many problems related to traffic congestion, housing shortages, the financing of the expansion, growing social segregation etc.

Will everyone have access to opportunities and a broad range of choices, or will the gaps between city and countryside and between successful and stagnating regions increase? Will it be possible to work globally but live locally, or will those who are educated and knowledgeable move to regions with a wide range of jobs, education and culture (3, 4)?

Will many people be pushed out of the labor market because they cannot handle the changes or because their company, town or region cannot handle renewal?

How will we allocate resources between financially strong urban regions and weak rural areas that cannot provide sufficient public services? Will we be able to finance the necessary expansions of infrastructure in major cities (3)?

Major cities (like Stockholm) and other growth regions (like the famously entrepreneurial town of Gnosjö) are attracting new residents. More and more people want to live in Sweden's largest cities and in other growth regions, which can also offer attractive residential milieus.

Flourishing growth of new businesses...

Under the heading "A richer and freer life…" we have already mentioned examples of new products and services listed by the various panels, with an emphasis on the individual and the user.

The panels also provide many other examples of new business concepts and growth opportunities for Swedish companies.

In all of the fields covered by the panels, these new concepts and opportunities largely revolve around IT applications. They range from health care to education: new health care services; sensors to regulate crop cultivation; local ideas for value-adding businesses; systems that improve traffic safety; "smarter mass transit"; "the wired traveler"; "direct manufacturing" that makes whole products in a single operation; mobile device technology; electronic services supplied by brokerage or "navigator" companies; the media, entertainment and cultural field; security services; as well as new courses and teaching materials for both domestic and international markets ("IT with a human face").

"Knowledge-intensive products" (6), "circular business systems" (4) and "intelligent transport systems" (3) can reduce environmental impact despite higher standards and consumption and increased travel. Perhaps "electronic paper" will increasingly replace newspapers (7), thereby reducing resource consumption. Paper will evolve toward increasingly advanced composites for different applications, including functional layers and surfaces (2).

The opportunities created by the new biology extend beyond health and food. New materials from renewable feedstocks will increasingly replace materials produced today from fossil petroleum. But they will also open the way for composites, new materials and products that utilize fibers as load-bearers and functional materials in surface layers (2). The use of vegetation as factories and new enzymes may allow efficient small-scale processes that compete with traditional large-scale processes.

The panels also mention other new materials: light, extra strong and resistant ma-

Smart cars! With built-in sensors, GPS and electronic maps, soon the car itself will be a better driver than most people. The result will be fewer accidents, lower emissions and more efficient energy use.

The sign says: Watch out for the bicyclist!

terials for mobile applications and for leisure items, smart materials with built-in electronic systems, as well as biomimetic materials that imitate nature's own materials (2, 6).

... but will it be possible to keep up with rapid international developments?

International competition is constantly intensifying, and development efforts are moving at an ever-faster pace. All major countries invest in IT, the new biology and technology in the borderland between physics, chemistry and biology. Given our level of resources, can we keep up with this often highly capital-intensive development work? Can we compete with countries that enjoy more favorable conditions in various respects, for example lower costs?

Another underlying but not always clearly articulated basic assumption is that Sweden's living standards and consumption must remain at a high level, but that our economy must become more sustainable, at the same time as harmful environmental impact must diminish. This implies additional challenges that must be met.

Several panels express concern about Sweden's shortcomings in terms of capacity for change, desire for change and flexibility. They discuss various types of rigidities in Swedish society, in companies, in organizations and in regulations. Will working conditions for entrepreneurs and innovators be sufficiently favorable (2, 4, 6)? Will companies, especially smaller ones, be able to handle the transition to new roles in changing global value-adding chains, for example in the engineering and forest product industries (4)? Will "technological muddling, skeptical attitudes and economics" slow Sweden down (7)? Can future IT systems handle disruptions, or will they suffer from "electronic epidemics" (2)?

And will there be a sufficient supply of labor with the right knowledge? For example in health care (1), food processing (2), the engineering industry and the service sector (4) as well as software development (5)?

3 A foresighted Sweden – knowledge and renewal

The preconditions for creating a foresighted society in Sweden are good.

This is evident from Technology Foresight's analysis of Sweden's future potential. Historical developments have been a major factor in creating this situation, but the reports also demonstrate unambiguously that continued good growth will require a great deal of fresh thinking and attitude changes.

These positive forecasts assume, however, that no currently unknown political or economic disasters, dramatic energy crises, large-scale environmental disasters or profound international crises will occur and, especially important, that Sweden does not "shoot itself in the foot." Faulty political/economic decisions, or a failure to make decisions, can destroy the best of preconditions in short order.

None of the panels were asked to focus exclusively on the important issues of environment and energy. Swedish Technology Foresight has instead chosen to let all of the panels weigh these factors into their analyses.

During the first half of the 20th century, Sweden created one of the world's best societies, with good quality of life, economic security, social services and growth. Aside from peace, our high and uniform educational level compared to most competitor countries played a large part in this success. A good interplay between technology and industry and between economics and politics was no less important. The role of the central government as a sophisticated customer in important industrial sectors meant a great deal to Swedish industrial development. The expansion of hydroelectric power, with the State Power Board (now known as Vattenfall) as the client, and later Sweden's heavy investment in nuclear power plants, gave ASEA (now part of ABB) a good starting position. Ericsson's growth occurred in fruitful collaboration with the government-owned Swedish Telecommunications Administration (Televerket, now Telia). The role of the Swedish Armed Forces in supporting technological development and in buying materiel was important to the country's defense industry and to some extent also its vehicle industry. The Swedish pharmaceutical industry received a powerful assist from the government's commitment to a comprehensive national health system.

During the second half of the 20th century, international competition gradually escalated, and with it the demands on Sweden. Over the decades, Sweden lost its leading position in a number of fields.

Today Sweden is a member of the European Union and thus has a considerably larger "domestic" market than previously, but must also observe new rules for procurement and government subsidies. It is no longer possible to develop technology, the economy and companies through intimate collaboration between the public and private sectors as before. The elimination of trade barriers and the EU's procurement rules have brought this kind of collaboration to an end. Meanwhile the deregulation of such sectors as energy and telecommunications means that the government can no longer be responsible for the otherwise difficult task of supplying capital.

On the other hand, open trade and free competition create new opportunities to broaden development resources and expertise through cross-border collaboration. The borders between countries, people and areas of knowledge are opening at an accelerating pace. Walls are falling – not only physical and political ones but also intellectual ones. Goods and people as well as ideas are flowing more freely, as well as faster and further.

Right now Sweden, with its tradition of free trade and its highly developed telecom and IT industry, has an edge and thus enjoys unique prospects to grow, expand and benefit from technological development.

For a small country like Sweden, it is especially important to decide in what fields it should invest its scarce development resources. Amidst growing competition, it is increasingly important to focus development work in a few carefully chosen fields, thereby achieving the critical mass that is necessary to bring about dynamic growth.

Numerous examples from such countries as the United States (Silicon Valley, Hollywood, Detroit) demonstrate the value of letting both companies and educational institutions cluster in one location and benefit from knowledge-related economies of scale. Kista, a district of Stockholm that has evolved into a world-class center of IT innovation, is an example of this strategy. In contrast, it may be risky to spread schools and other educational institutions around the country, basing their location on regional development policy arguments.

A sophisticated communications and IT structure does not replace the need for concentration and collaboration in geographic terms as well. Using centers of excellence as the base, the new technology provides major potential for building geographically far-flung networks.

Today Sweden is already at the cutting edge in information technology and molecular biology. But it is important to apply the advances in these fields to other fields as well. New opportunities often arise precisely when developments in one field are applied to a completely different field.

Among the preconditions for taking advantage of new opportunities, while counteracting the disadvantages of developments are:

- Good knowledge, especially related to new technologies and their applications.
- Strong research, especially in applications of the new technologies.
- A flexibility in companies and society in general that contributes to a favorable development climate.
- An infrastructure that promotes growth, especially in strong regions.

Sweden has good preconditions and can strengthen these by investing in, and further developing, a number of strengths such as:

- A system that provides a broad general education to a large number of people, the good knowledge and experience possessed by many individuals, a good knowledge of English, experience in using computers and telecommunications, an interest in technology and a tradition of adult education.
- Cultural strengths, including a tradition of mutual understanding between employer and employee organizations at the local and national levels and – on fundamental issues – between political blocs and parties.
- A consensus that has helped organizations and companies encourage individual initiatives and has given Sweden more informal, less hierarchical structures and bureaucracy than many other countries.
- An accepted – and often irreverent – openness and transparency in public dis-

People control technology! Technology and borderlessness are making it easier for a growing number of people to choose their own paths, whether in terms of work, leisure, experiences or finances.

course, in which the younger generation is particularly critical and questioning.

- A long industrial tradition, including strong exports in many fields – iron and steel, timber/paper/pulp, engineering products, vehicles, telecommunications, defense, pharmaceuticals. This has turned Sweden into a successful user of new technology and Swedish industry into a prominent supplier of complex systems products.
- In proportion to its population, Sweden has an unusually large number of internationally active companies and organizations, in which comparatively many Swedes have gained solid experience of advanced international work.

Among weaknesses that must be eliminated are the following:

- Several panels point to a lack of capacity for change in organizations and companies which puts Sweden at a disadvantage compared to important competitor countries.
- Rigid Swedish regulations and structures also hamper entrepreneurship and the growth of small companies.
- Comparatively high taxes on individuals make it more difficult to recruit foreign labor and risk encouraging talented Swedes to move abroad. The tax system also reinforces the already insufficient monetary incentives for higher education.
- Sweden has not made especially great progress in taking advantage of the reserve of talent found in the female portion of its population and among immigrants. Gender equality issues, such as the attitudes of girls to technology and science, are important to the future, along with people's attitudes toward immigrants and immigration. Greater diversity can help improve Sweden's ability to challenge established patterns.

The Swedish Technology Foresight project primarily points to two fields in which both the government and the business sector can and must take quick action and make concrete decisions to develop Sweden's strengths and eliminate weaknesses: education and infrastructures. Bringing about far-reaching changes will require new attitudes and fresh approaches among those who wield political and economic power, but also among the broad general public.

Attitudes for the future

We cannot plan the future. Attempts to do so easily result in large-scale but perhaps not always appropriate decisions that coming generations must pay for dearly. However, it is necessary to plan *for* the future. By preparing for a future that is uncertain and constantly changing, we can build a society that can face the future with confidence.

To enable Sweden to quickly enter a virtuous circle of development driven by greater knowledge and better infrastructures, new attitudes are required. All three of these areas are equally necessary, driving each other and thus the whole society in a positive direction.

Unlike many other important social changes, however, attitudes do not allow themselves to be influenced by single, easy and simply understood decisions. Even the most ambitious mega-investments cannot change people's attitudes.

At the same time, attitudes and the behavior that follows from them are what, in the long term, have the greatest impact on the development of a society. Changing people's attitudes is a protracted, laborious task that must be pursued at practically all levels of society.

The attitude that perhaps has more of a positive effect than any other on techno-

logical and social development is the desire for change. Openness to changes and eagerness to experiment are what guarantees positive social change.

The converse is true of societies where the predominant attitude is that it is preferable to do things as they have always been done. Even if this occurs while continuously improving quality, history is full of examples of industries and whole nations succumbing to competition because they were not sufficiently open to changes.

One important precondition for daring to make decisions about changes is the realization that there is no guarantee for the future. "Dare not be certain – but know and experiment" might serve as a motto for much of the work of Swedish Technology Foresight. The better the knowledge we possess about current conditions, the less frightening an unknown future will be. And those who have more knowledge also dare to test alternative solutions.

But it is easier to dare to make decisions about drastic changes if the preconditions that can be controlled are relatively stable: In other words, the rule systems in a society must always be made simple, comprehensible and durable. This is where Sweden has shortcomings that can be corrected.

Encouraging and increasing people's desire for change thus requires concrete decisions, both when it comes to structural and knowledge issues. Rule systems and institutions must be re-assessed, which several of the panels emphasize and – in what is one of the real main points of Technology Foresight – Sweden must increase and, in particular, radically change its commitment to knowledge, both in the form of education and research.

These three main ingredients for positive development – attitude, knowledge and structure – are also intimately connected. One will not change without the others.

For knowledge to be used and developed, a smoothly functioning physical and intangible infrastructure is required. Change requires knowledge, money and decisions. For these political and economic decisions to be made, new attitudes and a desire for change are required.

This is because positive curiosity is what drives the intensified search for knowledge and the wise infrastructure investments that are needed.

New attitudes are best created in the schools.

Knowledge

The guiding principles of Swedish education must therefore be a questioning approach, an openness to experimentation and diversity, and individually adapted education. To fill these principles with meaningful content, a radical renewal of our entire educational system, as well as on-the-job educational programs, will be required.

Behind these conclusions are three main factors:

- The precondition for continued and improved prosperity is a good supply of well-educated labor at all levels. The relative supply of people with university-level training in the natural and engineering sciences in Sweden today is substantially below the average for the OECD countries. Forecasts indicate that the situation will become worse, especially after 2010.
- To manage new tasks successfully, both companies and the public sector must offer continuous education and opportunities for everyone to acquire new expertise. Today almost all adult further education occurs only in the form of practical experience acquired in the workplace.

- Without more education, large categories of people will be forced out of the labor market, with devastating consequences for our society.

These three points are also important from an individual perspective. Sweden should give its young people a better start and give everyone better opportunities for personal development, whether we can see a direct benefit to the national livelihood or not. Good educational opportunities may also persuade people to stay or settle in Sweden.

The schools in the frontline

One of the most important talents that a student can learn in school is how to search for and assimilate new knowledge. The role of the teacher is changing. A teacher is becoming more of a guide and traveling companion on a journey of discovery than a provider of personal knowledge. This not only applies to higher education but also the regular school system.

One necessary prerequisite is that the school and higher education systems are in the forefront in terms of IT resources, and perhaps even more importantly, in terms of how to use them. Unfortunately too many schools have hardly even begun to take advantage of the new technology. Almost without exception, teachers lack good training in how they should use this technology and what role it should play and what opportunities it brings to teaching.

At best, today's attitude can be characterized as wait-and-see. Many people warn against an over-reliance on technological solutions, perhaps without realizing to how great an extent informal learning already occurs at home via television and the Internet. It is important to underline that the new technology does not pose a threat to the role of teachers. On the contrary, at all levels it provides new opportunities to improve and deepen that role. Perhaps Sweden's teachers are the most important target group for "lifelong learning"!

Lifelong learning

Above all, lifelong learning presupposes an enjoyable relationship with learning. Today a growing number of school youth are suffering from "school fatigue," which leads them to cut classes or drop out altogether. More and more people wonder what happened to the 6-year-old's joy of discovery on the way through the school system. Is our current school system – which was created in a different era – still serving its purpose? Does a school system largely based on the *imparting* rather than the *acquisition* of knowledge encourage children's irrepressible curiosity, or slowly kill it? And is it good for their learning motivation that students sit at school desks for 12, 15 and sometimes up to 20 consecutive years?

It isn't so hard. You click here, then …

There is also reason to question today's strict division of life into childhood, school, career and retirement, along with the division of each day into work time and leisure time. Perhaps work should be alternated with education by means of apprenticeship systems and institutionalized forms of further education. Shouldn't education be so enjoyable that it becomes a form of recreation, so that everyone learns because they want to, not because they must?

Swedish Technology Foresight believes that information technology has major potential to help bring about such a change. The whole world's collective knowledge is already accessible to everyone at home, at school and at the workplace. It is becoming easier for a growing number of people to assimilate this knowledge, because com-

munication between humans and computers is becoming faster, better and easier. Databases and teaching materials also employ a growing element of sounds and moving pictures to promote learning. In addition technology is making it easier to assemble individual educational programs, in order to create greater individual freedom of choice in time and space.

Education – not courses

Technology Foresight's perhaps most important reflection on education and knowledge concerns the widely discussed concept of "lifelong learning." This concept must assume a clearer, more concrete substance when it comes to adult education. Today there is not a great deal of systematic further education in the labor market. Occasional one-day training courses on how to use new PC tools or short conferences on project management or marketing should not be confused with an educational program, which perhaps means setting aside months or years in order to acquire new expertise.

It is important to create new opportunities to alternate work with education, perhaps by means of distance education at the workplace and new financing mechanisms. One problem is often that a company is pleased to see an employee acquire further education, but only if he or she stays in that company. Here new solutions are needed, perhaps on a collective basis by industrial sector, perhaps on an insurance basis. These solutions must, however, not lock people into their current job. Those who wish to move, perhaps from a shrinking industry into an expansive one, must also have the opportunity for education.

A multidisciplinary approach

It is becoming more and more important to have greater breadth and more multidisciplinary collaboration in higher education, and especially at the graduate or doctoral level. Old, established but perhaps no longer entirely appropriate approaches to the divisions and delimitations between the various sciences must no longer confine research. The panels see how different fields of science and technology are, to a rapidly growing extent, converging. Teaching and research institutions must quickly build powerful multidisciplinary environments and focus their resources on those fields where they have the greatest potential for prominence.

Today some of Sweden's most talented people remain doctoral students well into their thirties. In other words, during their most creative period, some of our brightest minds are busy – often in a narrow specialty – proving their qualifications for a future, "real" research career. Perhaps the creativity of these individuals could be put to better use by restructuring our system of graduate studies.

Undergraduate training must provide students with good basic knowledge of information technology and biosciences. This is particularly true of those who are studying natural sciences and technology, but it also applies to those who are studying social sciences and humanities.

Technological development has a major impact on national development. It is thus important, from a democratic standpoint, that as many people as possible have a sufficient knowledge of how this interactivity operates to be able to participate in public discourse on these subjects. Technology and science must therefore be assigned a larger role in social science and humanities education, and vice versa.

Infrastructures for renewal

Sweden's good infrastructures have been important success factors over the past century. This is true of both physical and intangible structures, including a smoothly functioning public administration.

These traditional infrastructures must be expanded and updated. The continued flow of people into Sweden's major urban regions requires the construction and maintenance of adequate housing, communications systems, day care centers, schools and hospitals. In this way, it will be possible to avoid bottlenecks that will hamper economic growth and limit people's range of choices.

To stimulate economic growth and generate resources to meet various national needs, the renewal of the business sector and public institutions must be facilitated and encouraged. Swedish political discourse is already dealing with a number of necessary measures, for example how best to create incentives for innovations, entrepreneurship and small business.

There is an obvious trend toward larger communications capacity, in which various types of telecommunications traffic are increasingly converging – telephones, radio, television, the Internet and telecommunication links between processors. New high-speed network connections will be an important success factor. The Internet made its breakthrough in Sweden rapidly, and our experience of this is overwhelmingly positive. The central government should, in every way, stimulate the expansion of high-speed connections to the entire population. In the best case, this may give Sweden a few years' edge in terms of research environments, telecommuting and technological maturity compared to many competitor countries. This may prove highly valuable in the dynamic developments that await us. Today it is indeed difficult to predict exactly what technological solutions will dominate the market, but this inability must not lead to passivity in relation to new technology.

It is important that there be *clear rules* for the business sector in order not to slow down its development. Here the new technology creates a number of practical problems. What are the rights of distributors of information and intellectual property in Internet e-commerce, and how should these rights be protected? When should people start paying tax for electronic bartering? What is the responsibility of the employer in ensuring the enforcement of working environment standards and working hour limits for telecommuters?

Today's existing rules may also be ripe for review. Rule systems must encourage flexibility and new working methods but also ensure employee security. The emergence of small "virtual" companies or networks – some with foreign partners – creates a new situation to which politicians, government officials, lawyers and the various employer and employee organizations have not yet devoted enough attention.

To an entrepreneur who is thinking about starting a new business, it is important to know clearly what ground rules apply. Conversely, it may give an entrepreneur a competitive edge if he or she knows what rules apply and know that the administration required by these rules is manageable.

Instead of letting developments force the adoption of new rules after the fact, thereby creating uncertainties for entrepreneurs and innovators, it is important that rules be formulated in a way that they are clear and foreseeable, yet allow room for new solutions and new businesses. This poses tough demands on rule systems to be simple, easy to keep track of and open to rapid changes. Perhaps a "Swedish Legal Foresight" project is needed as a complement to Technology Foresight.

In order to strengthen Sweden's competitiveness, Technology Foresight also recommends using various types of incentives to try to attract cutting-edge foreign expertise to Sweden and to encourage Swedish companies to invest in high value-added operations and in sophisticated products and services.

6 Summaries of the panel reports

Panel 1 Health, medicine and care

Demographic trends in the industrialized countries are creating both problems and opportunities for the health care sector. In 2000, one out of five Swedes is already over 65 years old, and the number is continuing to increase. This group will be a growing but attractive market for all players in the health care sector. These and younger patients will be able to choose from a broad range of health care options in a more deregulated market than today's. Whether the national elder care system can handle the growing number of older people will depend on how its financing systems are structured – an issue that should be placed on the political agenda as soon as possible.

IT will play an increasing role in the health care system: from providing patients with knowledge about their disease and serving as a tool for home care, to providing a communications platform for medical care professionals both locally and globally. Security requirements will become stricter, and the central government should have overall jurisdiction over all IT-based systems and services in this field.

The Human Genome Project, bioinformatics, ultra-rapid analyses using high throughput screening and other biomedical and technological advances will offer unprecedented opportunities to diagnose and treat diseases. But new therapies are more costly, and even today not all alternatives can be offered, due to strained finances in the health care sector. As in the elder care system, new financial solutions are required to ensure that the available range of health care options will keep pace with advances in medical research.

New knowledge about the role of genetics in health and disease will raise many ethical issues. What do individuals want to know about their genes? Shall their employer be informed if there are inappropriate risks? Can anyone patent a unique gene in a human body? Crafting responses to these and other questions should be assigned high priority, along with corresponding revisions of the laws that currently regulate these areas.

Today the Swedish pharmaceutical industry, which enjoyed a global reputation during the second half of the 20th century, is falling further behind its international competitors. The reasons, among others, are that most medical research takes place outside Sweden. As Swedish pharmaceutical companies merge with international corporations, there is a risk that additional important research will end up abroad. The trend toward mergers in the drug industry is likely to continue during the 21st century, and the growth of knowledge and the emergence of new pharmaceutical companies in Sweden are at risk. This will have an adverse effect on the health care system as well. Running clinical trials in the health care system is an important way of improving the system and of building up new knowledge.

Patient power, combined with an increased international range of health care and services and a relatively high willingness among individuals to pay for part of their health care with their own money will place unprecedented demands on the

Swedish health care system. Health care employees will, of course, become increasingly specialized, but in the future the financing and the provision of health care should be separated from each other in order to speed up the decision-making process and better meet the health care and service needs of tomorrow.

Panel 2 Biological natural resources

The panel discussed developments from a user perspective, paying attention to products or goods from biological raw materials – both traditional applications related to agriculture and the food processing industry as well as forestry and the forest product industry, and alternative or entirely new applications.

Vision for 2020: A knowledge explosion that creates a "biological revolution"

In 2020 we utilize biological natural resources in a sustained way. New products and materials and new production processes contribute to economic growth and employment in the new international market that has emerged.

The knowledge explosion in microbiology, biotechnology and genetic engineering, the "biological revolution," has enabled us to control and customize plants to create the desired characteristics, as well as to develop foods for the needs of individuals. This has provided a basis for environmentally friendly and resource-efficient production of raw materials for food and other products and production of innovative new products. We have learned to use whole trees and crops to extract various materials and energy in integrated value-added chains and processes. Ecocycles have been closed through recycling of the materials and energy from organic wastes. We have learned to emulate nature's own solutions and have developed materials with characteristics superior to those of traditional materials.

The industries that process raw materials from forestry and agriculture – the wood products industry, the pulp and paper industry and the food processing industry – focus on customer adaptation and far-reaching refinement of raw materials into competitive products.

What drives development?

As important driving forces, the panel singled out globalization and its consequences in the form of increased competition and consumer power; changed values and new lifestyles resulting, among other things, from urbanization and greater mobility; and people's interest in nature and the environment, with sustainability, climatic issues and health as central concepts.

Other important factors are greater knowledge and new technology, which are creating the preconditions for a trend toward better, all-round utilization of biological natural resources: information technology, molecular biology, bioinformatics, sensor technology and new knowledge of materials.

New knowledge lays the groundwork for the "biological revolution"

Today molecular biology and biotechnology in the broad sense (life sciences) have already yielded entirely new knowledge about the structure and function of the

biological system, opening up new ways of creating new products and materials and of remedying many of today's environmental and health problems. The continued expansion of knowledge will also clarify connections between diet and health, making it possible to formulate diets and produce foods that contribute to health and well-being. Plants can be customized and cultivation can be made more efficient. New process engineering can reduce resource needs during the manufacturing of products from biological raw materials. New knowledge about wood and plant fibers, along with knowledge of materials and surface layers, can make it possible to develop highly functional, innovative products.

Meanwhile, these new opportunities entail risks and raise many ethical issues. It is necessary to conduct an open public dialogue about the uses of the new technology, a dialogue in which researchers in particular must become involved and must explain the preconditions, opportunities and risks of this technology.

Development of important applications

The two basic industries that use biological natural resources, the forest product and food processing industries, face major challenges as a consequence of globalization, increasing international competition and restructuring as a result of new technology and deregulation.

To survive in the long term, it is necessary to focus increasingly on customized quality products with a high knowledge content. For the Swedish paper and pulp industry, this implies a concentration on the advantages of long fibers. For the wood product industry, it will be necessary to use our wood varieties and process them into finished products. For the food processing industry, it implies further refinement of our high-quality raw materials, with a focus on quality, safety and health-related products.

There is great interest in new applications and new materials from biological natural resources. Sweden should invest in developing new solutions and opportunities in which specific, valuable characteristics of the biological materials are put to proper use, in fields where we have well-established industrial operations or knowledge, such as in packaging or materials.

Biological natural resources can also supply domestic, renewable fuel and provide new opportunities for rural areas to achieve economic growth and to gain new vitality by means of local, small-scale production of high value-added products, among other things in combination with recreation, culture, tourism, hunting and fishing.

What should we do?

Our strategy should aim at creating good preconditions for the further development of important branches of industry as well as building up good preparedness for action. This should be based on fields in which we have:

- good preconditions: slow-growing trees with long fibers, climatic advantages for healthy cultivation and animal husbandry, as well as crops that suit our climate
- good knowledge: biotechnology, genetic engineering, chemistry, biology, plant breeding, cellulose and wood
- a strong business sector: the forest product, food processing, energy and vehicle industries.

Our strategy should focus on developing products with a high knowledge con-

tent, developing sustainable and efficient cultivation and production systems, and building up a necessary and large knowledge base, including collaboration across the boundaries between subject areas and between research and business.

Our proposals for actions consist of a concerted commitment to three national programs and a commitment, shared by all three areas, to entrepreneurship:

I A comprehensive program for the development of expertise and innovations in biotechnology (life sciences), including investments in cutting-edge knowledge; in strong research environments with expertise in molecular biology, biotechnology, genetic engineering, IT and materials technology; as well as in improved education on the new biology and biotechnology. We also propose vigorous measures to stimulate innovative activities and entrepreneurship with ties to research ("Bio Valleys"). This commitment should also include the creation of meeting places for dialogue and active communication with the general public concerning genetic engineering and biotechnology.

II A clear, comprehensive strategy for industrial and sustainable use of Swedish forests, drafted with broad participation from all affected stakeholders, including investments in internationally outstanding basic research in the pulp and paper sector, as well as new, high value-added products based on fiber and wood as raw materials.

III A national strategy and action program for the entire food processing field, from primary production to retailing. This program shall aim at a broad improvement in expertise and better coordination of the entire production chain, with a focus on consumer and marketing knowledge, process and production engineering and innovative products. Effective development of knowledge concerning the role of diet in health will require a special commitment to establishing meeting places for food processing-related and medical researchers.

IV A commitment to the promotion of all types of start-up companies and entrepreneurship based on biological natural resources, to make it easier for small companies to gain access to knowledge and protect and develop innovations; to promote access to risk capital; to simplify regulations and legislation in such a way that start-ups encounter a uniform set of rules and reasonable requirements; and to promote the development of rural production based on biological raw materials.

Beyond these concerted programs, the panel proposes commitments to:

- Developing new applications and new materials from biological natural resources and to research on nature's own solutions or materials for different functions.
- Research and education on environmental and health aspects related to the entire supply and use system for various forms of bioenergy, as well as development of integrated processes for efficient production of electricity, fuels and chemicals/materials/raw materials. Development of cultivation systems which, aside from energy production, are also utilized for purification of wastes and recycling of nutrients.
- Development of need-based sensor-rich systems to optimize the production and processing of our biological raw materials.

Public sector measures will naturally focus on financing and stimulating research and education, as well as creating a business climate that encourages innovations, risk-taking and growth. The panel also recommends that companies focus on products with greater value-added, market orientation and customer adaptation.

Panel 3 Society's infrastructure

A new time of transition

The image that emerges of Sweden's infrastructure twenty years from now indicates that at the turn of the 21st century, the country once again finds itself in a time of transition. The Swedish industrial society and welfare state of the past century, with its strong public sector and its faith in large-scale solutions, well-established institutions and social engineering models, is no longer sufficient. New conditions and solutions are materializing.

Regional relocation is continuing in Sweden, and this involves a major transformation. It will thus be a challenge for Swedish society to solve the divergent problems of depopulation regions and growth regions. A more market-oriented housing sector, a new approach to the automobile and other modes of transportation, and a changed allocation of roles and expertise between the private and public sector are other traits of tomorrow's Sweden.

Panel 3's report describes the changes in demography and infrastructure during the first decades of the new millennium. The report outlines major changes in population structure, construction activity, communications and institutional conditions. The report does not express the desires and visions of the panel participants, but instead shows the relevant changes in our country and society that the participants believe will have the greatest influence on man-made infrastructure.

Diversity will characterize regions and cities

The first decades of the 21st century will be characterized by continued shift of population to attractive regions and cities. Generally speaking, this flow will go from smaller towns to larger ones and will have major repercussions for the country. In 2020, Sweden will be more differentiated and specialized than today. Each region will try to project an image of itself based on its natural potential.

Regional development policy will have changed. There will be a strong awareness that each region must take advantage of the opportunities that exist locally and develop these based on its own potential and for its own benefit. The central government will find it necessary to deal with the problems of depopulating areas and of growth regions at the same time, without allowing this to create conflicts.

Cities, too, will be characterized by internal differentiation and diversity. A city is an important meeting place and arena and plays a central role for trade and economic growth. The hospitality, event and tourist industries will become economically more and more important. There will be major efforts to ensure that Swedish cities can attract events, conference and tourists. The new regional landscape, characterized by greater interaction between a regional center and the surrounding rural areas, will have become more important.

Higher-density cities with better utilization of existing space

Urban values will be increasingly appreciated. The new generation will have grown up in cities and will consider them a natural living environment. Throughout Europe, we can observe a pattern in which cities grow within the limits of their existing structure, not by expanding their urban area outward. Cities are becoming denser, and development is filling in the unused spaces. Existing resources are being utilized at the same time as they are being transformed. The result is a diversity that many people find exciting and appealing. There is a shift away from

expansion and new construction toward more efficient use, retrofitting and additions to existing buildings and facilities.

There is a growing need for action in "modern" built environments. During the coming 20- year period this will require substantial investments. We may need to develop models for how to renew the mass-produced housing developments of the late 1960s and early 1970s and other "modern" structures, models that go considerably further than the cosmetic investments to date. These housing developments represent both opportunities and risks.

Sweden's three largest urban areas can be expected to become more multi-centered. While city centers will become increasingly attractive to both households and businesses, many people will choose to move to attractive cities in the surrounding area. Our largest urban areas are in the process of becoming multi-centered regions. More centers are being formed in the Lake Mälaren region in addition to central Stockholm. The same is true in the Gothenburg and Öresund regions. Entirely new city centers may emerge near junctions in the regional traffic network. The question is whether these will be in the nature of large retail centers or whether they can become full-scale urban neighborhoods of a new kind.

Similar processes are taking place in areas outside the three major urban regions. They are mostly occurring in a group of cities that are collaborating, aided by good communications and transportation. The range of businesses, activities, culture, tourism etc. that a region can achieve is being concentrated as much as possible, so that the region as a whole will be strong in competition with other regions in Sweden and elsewhere in Europe.

Flexible and varied markets for housing and commercial space will take over from standardized and uniform ones

During the coming twenty-year period, new construction will be at a lower level than during the immediately preceding twenty-year periods. Public sector financing and subsidies to the housing sector will diminish. We will move away from a system where people are assigned housing to a residential market in which construction is no longer stimulated by public subsidies. Due to population changes, it is likely that the pattern that characterized housing production after World War II may continue, with fluctuations between periods of very low housing construction and peak periods.

There will be a trend toward a growing proportion of real estate capital being individually financed: a growing proportion will consist of household down payments or mortgage loans. In attractive locations, most housing will belong to tenant-owned cooperatives. New housing will be built for affluent people. Housing will continue to absorb a large proportion of disposable income in the future, leading to a different size standards and more varied solutions than previously. The housing market will increasingly operate under market conditions. More housing will be built directly on demand. The housing market will continue to be socially segregated, in any case in our largest urban areas. In the least attractive residential areas, upgrading and renovation will occur, also including traffic solutions.

Looking at our use of commercial space, we find that for many years it has already been market-controlled. This will be even more true in the future. The mobility and flexibility that characterize the commercial space market will be further accentuated by e-commerce, home offices and virtual companies. Boundaries between home and workplace will become increasingly blurred.

Existing transportation infrastructure will be upgraded and environmentally and logistically adapted

Over the next few decades, the existing transportation infrastructure will undergo radical efficiency improvements and upgrading. This applies to infrastructure for all modes of transportation. We will try to squeeze as much use as possible out of existing facilities. This is partly a practical necessity, because the problems of gaining acceptance for construction of new facilities, which often infringe on the landscape and generate local public opinion that is politically difficult to manage, are expected to become larger and larger.

Even today, the main tool for upgrading the transportation infrastructure is IT, which has suddenly provided completely new, "intelligent" ways of utilizing existing facilities more efficiently, but also of making traffic safer and more environmentally friendly.

By 2020, we will see travel in a different light. Our relationship with the automobile will no longer be a major issue. Smooth transfers and payment systems will make it easier in every situation to utilize the most convenient and optimal means of transportation. Travel centers will play an even more important role in the future and serve as important nodes in the intermodal transportation system, in which emission-free rental cars will be used as part of everyday travel.

Infrastructure will be financed less by taxes and more by user fees and via the capital market

New infrastructure is needed and will be built. In Sweden, investments in transportation infrastructure have so far mainly used public funds and appropriations from the central government budget. This is also the norm in other countries. Here a change will occur. New mechanisms for the financing of infrastructure that are being tested in a number of countries and are connected to a new allocation of roles between the public and private sectors. They will also be applied in Sweden. We are seeing a trend toward joint public-private sector projects.

Infrastructure is being less heavily regulated. Instead it is being expanded in project and package form. Alliances including many participants are carrying out major infrastructure investments. This "projectification" of infrastructure must be reconciled with our efforts to ensure democracy, user influence and competition.

The changes underway in other countries provide a hint of how the transportation sector, especially road and rail, will develop in the future in Sweden too. This may involve the granting of concessions, which normally means that during a certain period, private interests will have the opportunity to develop and operate portions of the highway network, for instance. Quite soon, road tolls will start to be levied for heavy vehicles on the national highway network, but it is more difficult to introduce tolls for private cars, especially in built-up areas. In the long term, road tolls will be introduced and accepted in Sweden, partly as a consequence of their introduction in many other parts of Europe.

New allocation of power and authority

Today, and for the foreseeable future, there is a shift in a more market-adapted direction and toward greater internationalization. Meanwhile individual consumers wield growing power over production. There is rising demand for more environmentally adapted and experience-oriented products. Demand is becoming more differentiated. In many fields, the driving forces for systemic change are institutional and social rather than technological, but technological development creates potential that new institutions take advantage of.

In the infrastructure field, until now the public sector has passed laws, made deci-

sions, financed and constructed. But the public sector's financial resources no longer suffice for investments in the infrastructure to the same extent as before – either for subsidized housing construction or for directly depreciated traffic facilities. Telecommunications and water/wastewater systems are already being financed by fees, and not as part of public sector budgets. Public sector economic resources are increasingly needed to fund education and social services, especially for the growing category of older people. Investment capital is instead being found in the private sector, largely from pension funds. This capital has to be invested in a financially safe and consumer-friendly way.

Mechanisms of collaboration require a new working method and a higher level of expertise from all those involved: everyone must improve their know-how. We need to find smoothly functioning models for signing agreements and for operating either in the role of client and standard-setter or in the role of supplier of services and infrastructure. Negotiations may, in successful cases, give all interested parties more than they could have achieved on their own. This requires that all parties have their own objectives, priorities and purposes, and that they can clearly communicate them to the other parties. This often creates opportunities for interesting combinations.

Panel 4 The production system

Sweden has a long tradition of industrial production, including large engineering, electronics, forest product and steel industries. Major changes have occurred. For example, the Swedish shipbuilding and textile industries have nearly disappeared, while other industries such as the production of mobile telephones and vehicles have experienced vigorous growth.

The production system in the broad sense includes many value-adding stages, from raw material and component suppliers to the customer/user. Both development and production are central concepts, in which the choice of how and where manufacturing occurs is controlled by the choice of technology and design.

Information technology and globalization will force far-reaching reforms in traditional production systems. They must be reformed in ways that enable them to cope with rapid changes and take advantage of greater mobility and access to information. Their expertise must be improved in such a way that these systems can cope with the transition to new products and new production technology, including a sharply increased element of IT, software and services. The new information economy provides a large potential market – and increased competition.

So how will our future production system look? What path should Sweden choose to maintain its position as a strong industrialized country? What do we need to do to prepare ourselves for what may happen in the future? Do we have enough labor, and does it have the right skills?

The departure point of the production systems panel of Swedish Technology Foresight has been to formulate a strategy to enable Sweden to continue developing as a successful industrialized nation. The basis for this strategy is the future trends that the panel has sketched and the review of Sweden's preconditions that it has undertaken.

The future: trends affecting the production system in 2015

The future scenarios presented below point to changes that may break through on a large scale and then have a major impact on production systems and Swedish society. The purpose of these scenarios is to illustrate lines of development in order to understand Sweden's changed needs for expertise and to identify strategies for responding to future challenges.

The customer wants individualized products

Individualization and customer adaptation have become crucial competitive tools. The customer is able and willing to determine the function, design and characteristics of products. Environmental impact, recyclability and ethical issues are of importance. Individualization is based on volume production of well-defined modules as well as final adaptation close to the customer. Manufacturing is becoming more and more high-tech.

Individuals and companies can live locally but work globally

In 2015 we will be independent of our actual geographic abode. Telecommunications and mobile equipment will enable us to collaborate directly and closely with people all over the world. Rapid physical transportation will mean that we are always centrally placed. Manufacturing can be handled by local manufacturers at flexible plants. Capacity for change and contact networks will be vital competitive factors. The local environment will be important, however: development, innovations and creativity are favored by access to broad expertise and knowledge in strong regions.

Production and product development are pursued in project form

As a result of calls for flexibility and rapid changes in production systems, production in 2015 is pursued in project form, including collaboration within and across company boundaries, or "virtual companies." The brand name and the product are owned by a product owner, while detailed development, further refinements, production adaptation and manufacturing are performed by those who can offer the best conditions. People in these temporary project organizations face competition in the form of a constant pressure to be the best. Permanent employment is unusual and has been replaced by various kinds of agreements between project management and the individuals involved in the projects.

Circular business systems: closed resource flows and sale of functions

Closed ecocycles have been introduced for both environmental and economic reasons. Companies no longer sell physical products, but functions, including both a service element and a material element. The customer rarely buys an entirely new product. Instead, companies own and modernize the product as needed. Companies develop long-lived hardware, because it is utilized throughout its technical service life. One obvious consequence is that new production of hardware has decreased sharply, whereas maintenance and care of products has increased, along with reuse of materials and components.

Intellectual capital is the most important means of competition

High knowledge content in products, project-based work and free forms of collaboration inside and between organizations have made intellectual capital the most important means of competition. Production is based on in-depth knowledge and a high level of expertise in both development and manufacturing. The element of services in products has increased dramatically. Companies invest systematically in achieving a high inclination to change by means of investments in intellectual capital, both in structure, i.e. organization, working tools, procedures

etc. and in human capital, i.e. employee knowledge and skills. A new generation of people has emerged who have learned to educate themselves in a lifelong learning process at work.

Why we believe in these future trends

Globalization a driving force

The globalization of the capital, product and service markets is subjecting today's Swedish business sector to strong pressure. Various countries are competing by offering low taxes, favorable rule systems or investments in new infrastructure.

Competition will be ferocious

Free trade and the Internet are making trade global. International corporate groups are building up flexible production systems in which specialized global subcontractors have steadily gained in importance. Competition for both manufacturing assignments and advanced tasks in the production system is escalating.

Technology provides new opportunities

Microelectronics, computer and communications technology, along with biotechnology and new sensors and materials, will create entirely new products and fundamentally change the nature of manufacturing. Simulation and modeling will lead to entirely new working methods. Later on, direct manufacturing and nanotechnology will provide additional opportunities.

New values are changing markets and companies

Environmental and sustainability aspects, as well as gender equality and diversity in the labor market, have become very important and are a strong driving force for change in the industrialized world. Values are increasingly international and new trends make rapid breakthroughs.

Focus on brand names and core competency

The most vital features of a company's business are its brand names and its core competency. Manufacturing is being outsourced. Products are being given a large knowledge content and are being combined with services. It is becoming important to be first, to gain exposure for the brand and to be "first to mind."

The customer is becoming more and more important

Individualization and customer adaptation are driven by companies in order to gain competitive advantages and expand their market, and by consumers who want greater freedom of choice. The necessary rapid changeovers in production are handled by means of modularization and use of technology platforms. Mass production of general modules can be combined with small series in final assembly.

What are we good and bad at – and where are the opportunities and the threats?

Sweden's strengths are a solid industrial tradition, experience in systems thinking, a good knowledge of languages and the use of IT, a business culture suited to a project-oriented working method, and an infrastructure that is well-developed in many respects.

Sweden also has weaknesses. Our domestic market is small, and our distance from important markets and business partners is a disadvantage. High taxation of indi-

viduals and relatively low salaries for highly educated people make it difficult to recruit foreign personnel and to bring home Swedish personnel from other countries. Rigid rule systems and structures hamper the growth of small businesses.

Business opportunities are found primarily in growing international markets, in the creation of new alliances, in the use of the Internet and in systems-building. Sweden's environmental awareness and experience of modern technology make it possible to find domestic customers at an early stage for new, complex technology.

There are a number of threats: a lack of desire for change in companies and public institutions, stiff competition from countries with low costs for both simple and highly educated labor, as well as a lack of interest in technology, industry and entrepreneurship among young people. Another threat is that research in production engineering and product development is being given inadequate resources.

A strategy for Sweden

What strategy shall Sweden choose in order to become the best at industrial processes, maintain its role as an advanced systems supplier and create new products and services? How shall we prepare ourselves for the developments listed in the above future scenarios?

The panel proposes that Sweden invest in developing further as an industrial nation and in becoming the best at industrial processes. Sweden should do this by increasing its capacity for change, by establishing broad collaboration arrangements and alliances, by focusing on high quality and safety, by having a positive attitude toward services and by investing in new business opportunities in improved resource-effectiveness and ecocycles.

Sweden must build structures for innovation

Vigorous investment in important fields of technology

Knowledge and expertise must be strengthened in fields of strategic importance for production systems, such as integration of IT and software in products and production systems, advanced manufacturing techniques, modeling and simulation, methods for development of complex systems, material and production engineering and life-cycle economics.

Interdisciplinary collaboration in traditional fields of knowledge

There must be an emphasis on greater research collaboration between the higher education system, research institutions and companies that cross the boundaries between fields of knowledge and between industries. A special effort should be made to promote exchange and rotation of researchers between the higher education system, research institutions and the business sector, as well as services and incentives for small and medium-sized companies.

Concentration of resources

It is necessary to concentrate national resources on investments that will provide sufficient critical mass at selected institutes of technology and universities. Sweden is too small to build up expertise in all fields at all locations. Advanced production engineering research should be located at those places that have the best potential. At the same time, an attractive program of higher engineering education should be created at many locations.

Rapid communications

Sweden needs a major expansion of its communications systems. High-speed, se-

cure fixed and mobile communications networks are necessary in order to work efficiently in networks and projects. The physical transportation infrastructure needs to be expanded to provide efficient goods shipments and rapid human travel.

Flexible regulations

The public sector must quickly review its regulations and legislation in order to promote the establishment and growth of small companies and facilitate the work of project organizations, including those that work across company, industry and national boundaries. Sweden needs to harmonize the economic conditions and regulations affecting such companies and organizations with those of other countries.

A rapidly changing world is placing new demands on companies and organizations

Capacity for change and new working methods

Companies and organizations need to improve their expertise in dealing with change, by means of education, more flexible working methods and dynamic thinking. Management needs to adapt to network-based projects and to rapidly increasing the content of IT, software and services in their products. Companies must change their roles in response to global competition.

Strategies based on intellectual capital

Companies must base their strategies on intellectual capital instead of physical capital. Structural capital should be developed through simulation, modularization and project orientation of operations. Human capital should be developed through education, skills training and changes in work assignments based on lifelong learning and flexible working methods.

Circular business systems based on ecocyclical thinking

Companies must develop circular business systems based on the sale of functions, ecocyclical thinking, life-cycle thinking and design for recycling and reuse.

Panel 5 Information and communications systems

The panel has identified seven key areas by formulating visions of future society and describing what technology is required to achieve them. These seven areas will be of great importance to the future evolution of information and communications systems.

The conclusions of the panel's work provide the basis for a number of strategies for the Swedish innovation and knowledge system. The purpose of these strategies is to serve as driving forces for developments in one or more key areas that will enable Sweden to become a world leader in these areas and thereby attract expertise and capital.

Key areas

The first key area, *Always Online*, describes a development in which people, independently of time and space, communicate electronically with each other, their homes and workplaces or with various services on the Internet. This does not mean that they are always personally accessible, but that their communications can be handled via a personal communicator. This area is characterized, among other things, by the development of home networks and wireless communications and by the convergence of different media. The area offers technological challenges, for example due to the need for greater bandwidth and new, improved interfaces between people and machines.

The area called *The Digital Assistant* singles out the need for software that can independently examine and interpret information and adapt it to the situation and requirements of the individual. The explosion of available information and the growth of e-commerce require advances in such intelligent, adaptive systems. In order to meet these demands, we need standards, sensors and improved techniques for retrieving, interpreting and evaluating data.

Current and future development in IT clearly shows that *More and More is Becoming Software*. Large portions of the functions of hardware can be performed by software, which may be freestanding or integrated into hardware. This increases the demands on tools to produce software, and there is a need for new methods of programming, packaging, distribution and recycling of software. The design of intuitive interfaces is a major point.

One consequence of improved software tools is the possibility of customizing more and more services and goods, which will increase availability and make the production of new services possible. This is described in the key area known as *The Services of the Future are Electronic* and includes e-commerce in both physical and information-based products and services that presuppose electronic communication. New opportunities for bringing together buyers and sellers are driving the creation of new business models. The value of customer information and brand names is increasing. Important prerequisites for this area include greater bandwidth, new standards, better payment systems as well as delivery and quality control.

Education and expertise are becoming steadily more valuable. More and more people have knowledge-intensive job assignments and thus a need for *Continuous and Immediate Learning*. Education and work will coalesce, in the same way that the entertainment and game industry will be linked with learning. With the help of IT, educational material can rapidly be disseminated to many people and be adapted to the individual. If advanced interactive educational programs are to make a breakthrough and become available, they will require carefully conceived teaching methods, software tools for the production of educational materials, functional interfaces and greater bandwidth.

Developments in the borderlands where *The Technological and the Biological Worlds Meet* will be important in biologically related businesses. But biological knowledge also provides opportunities for new applications for the IT field. One strong driving force is the miniaturization of electronics. This area also includes biosensors and artificial senses, where such products as hearing implants and haptic (touch) interfaces already exist. As for the use of biomolecules as electronic materials, numerous challenges remain to be mastered before these techniques will be functioning and commercially viable.

The last key area raises issues related to *Security and Privacy*. Increasing opportunities to gather information about individuals and their behavior may threaten personal privacy. The society of the future will also be vulnerable, because central portions of it will be dependent on information technology. If the use of IT is to continue its positive growth, people have to trust the technology. This requires a new legal package, including a combination of laws, agreements and self-regulation, as well as technological solutions to ensure security.

Strategies

The panel proposes the creation of a Swedish "IT university," with an emphasis on mobile telecommunication systems. This university should be organized in the form of a number of nodes tied together into a network, which also collaborates with other universities and higher education institutions besides purely technical ones. The universities should collaborate with the business sector, among other things exchanging teachers and further education programs. One important element of the university is a focus on multidisciplinary programmers who can develop software tools.

The panel recommends putting Sweden's schools online to promote development and stimulate new meeting places. Via the higher education and schools systems, the central government should first procure a backbone for all universities and colleges and thereafter extend it to the compulsory and upper secondary schools.

The meeting of the technological and biological worlds is described as the core of many future technological advances. The panel proposes an effort to build up expertise and applications in molecular electronics, in which biomolecules are used as building blocks for electronic functions. The symbiosis between biology and IT requires multidisciplinary environments and programs.

The development of IT interfaces for all people is central to several key areas. In particular, interfaces for all the human senses are critical. Today there is a shortage of resources and entrepreneurs for this. The panel therefore proposes an interface program, preferably under the auspices of the Interactive Institute. Another area of interface development is systems science for groups of autonomous systems. Sweden should have a project or research program for such systems. The program can deal with both physical and mechanical robots, as well as software agents and autonomous systems. There is great potential for applications in areas that interpret large quantities of data, for example e-commerce, health care or self-care.

The panel proposes a network for security and privacy in information systems. Individual privacy and broader security concerns are important factors in the development of the IT field. The business sector has a commercial interest in protecting its digital infrastructures from both physical and network-related attacks. The public sector has the same interest. This network would be responsible for follow-up and analysis of deliberate IT attacks throughout society. The need for exchanges of information is increasing, as is the need for collaboration in the build-up of expertise related to threats, attacks and various protective measures.

The panel also presents a strategy to enable travelers and transport systems to be always online. This proposal involves an analysis carried out by the National Road Administration as well as the development, among other things, of electronic services, sensors and adaptive systems tailored to travelers and traffic systems. The Road Administration could make its registers available on a mobile basis and provide information on the traffic situation and accident risks. At a later stage, the strategy could include other parties, such as the automotive industry and logistics companies.

Finally, the panel recommends a specific strategy for IT in the health care and social service systems. One part of this effort is a program for home health care. The program should enlist researchers, companies and public institutions to jointly develop innovative products and services for caregivers, other affected organizations and patients. One or two hospitals in Sweden can operate pilot projects. Because future health care will involve expanded patient contact on a remote basis and a larger element of home care, there is also a need for realistic experimental milieus where this type of solutions can be developed. One such milieu is the proposed intelligent bathroom.

Panel 6 Materials and material flows in the community

Knowledge-intensive products

By virtue of its strong industry, Sweden has a well-developed base of expertise in the materials development field. Over the next 20 years, industrial society faces a transformation which, to some extent, has already begun in Sweden – from a focus on "throwaway" products to a user focus that includes demands for ecocyclical adaptation and resource-efficiency. It implies an emphasis on whether products fulfill specified targets, and this is very much true of the materials used in products that are becoming increasingly advanced and functionally adapted. We see great potential for the Swedish business sector to participate in the development of the society of tomorrow, not only in Sweden but also in the international market, provided that we are aware of this transition and that we stimulate its driving forces and eliminate existing obstacles.

Resource-efficiency is largely driving technological development in the materials industry. Examples of driving forces are improving efficiency, conserving energy, economizing on materials, optimizing service life and creating more efficient, simpler material production processes. From the perspective of materials development, the focus is on material characteristics and functions. Material selection and customer adaptation are also important for product target fulfillment and thereby contribute to greater resource-efficiency. In light of this, the education system must switch from today's system based on separate academic disciplines to an education in materials science that combines physical, chemical, mechanical and biological aspects and that evaluates materials in a life-cycle perspective.

The demands for optimal service life lead to two possible extremes: either products with a short service life that we can recycle or burn, or products with a long service life that can be reused, repaired and updated.

The global development and dissemination of information technology, together with advanced logistics systems, is leading to greater availability of many raw and standard materials in the international market. Search engines, stock markets, competition for procurements along with globalization are creating keener competition but at the same time are opening new opportunities.

There are business opportunities either in economies of scale or in highly specialized products with a large knowledge content. Swedish materials technology-related companies are better equipped for the latter case and for a vision of "knowledge-intensive products" based on advanced expertise in fields where Sweden has comparative advantages. Knowledge-intensive products may, for example, include technology-intensive and highly functionalized materials, but simpler materials may also be employed in a sophisticated systems solution.

Articulating the needs of the future

Materials development in Sweden has traditionally taken place in a close dialogue with advanced standard-setters and knowledgeable suppliers. This method has been successful and should also be used in the future. However, the standard-setters previously often had ties to public agencies or to national needs – this has been true of development work in the defense industry, pharmaceuticals and hydroelectric power supply. In the future, the standard-setter is increasingly often the end customer. This also applies to companies that operate in the business-to-business market.

The development of knowledge-intensive products must take place in close collaboration with world-leading material suppliers and research environments – in Sweden or abroad. Having geographic or cultural proximity to a number of such players is necessary for successful entrepreneurship. The panel believes that the market/customer as standard-setter is an important driving force, which makes it important to be aware of changing values in society. How do people want to live in 15–20 years? What needs will they have? What does this imply for technological development?

The panel believes that Sweden is an attractive test market, among other things because of its population's high IT adaptation, advanced expertise on health and environmental issues, interest in other cultures, good language skills, varying climate and broad spectrum of ethnic groups. We can utilize these factors as comparative advantages in technological development work.

Focus on intensive materials know-how

The material categories that should enjoy priority are light, extra-strong, resistant materials and smart materials. The latter implies a combination of modern semiconductor technology with materials technology to produce materials with one or more built-in functions. In this field, sensor technology is important.

Biomimetic materials – which imitate nature's material structure or functions – are one area that is attractive for a number of different applications, due to biological adaptability and nature's efficient ways of building materials or implementing processes.

Opportunities to develop new types of materials, for example materials combining surface and thin-layer technology, nanotechnology or new chemical synthesis methods with advanced material analysis, should receive high priority.

Likewise, computer simulations of material characteristics based on quantum mechanical theory and atom composition are a usable and cost-effective tool for designing and testing new materials. It is even possible to begin attacking the problem conversely – what materials or combinations of atoms in materials can yield the desired functional characteristics?

Focus on technological development with a market and user perspective

Just as important as a profound knowledge of materials is the ability to rapidly adapt materials, products and the production stage to final manufacturing. This requires the development of materials engineering and process control technology, in which modeling and simulation are important tools. Market adaptation also requires knowledge of the environmental and health effects of materials and of functional design and ethical values.

Platforms for developing this perspective need to be created in collaboration between industry, universities and research institutes.

Strengthen incentives for entrepreneurship and for innovation infrastructure

We must reexamine the Swedish innovation system as a whole to identify incentives at all levels and for all players, from concept to enterprise. This is especially true of university-level educational programs. We simply believe that entrepreneurs and innovators must be made into the heroes of tomorrow!

Panel 7 Service industries

The service sector has become increasingly important for Sweden's future. This is evident, among other things, from the statistics available as this report is being written. Of the 28,000 companies formed in Sweden during 1998, no fewer than 80 percent were service companies.

Many of the new companies operate in fields that have come into existence as a result of technological advances. These advances create preconditions for new kinds of entrepreneurship and lead to changes in traditional industries. By quickly embracing these new opportunities, we Swedes have gained an edge. Holding on to this leading position and take even greater advantage of future opportunities will require, among other things, that we invest in research, both in technology and in new fields of services and entrepreneurship.

Other factors also affect conditions under which companies and people work. This is especially true of political decisions. Europe has become the "domestic" market of Swedish companies. The role of borders is diminishing throughout the world. Trade is becoming global. So are labor, knowledge and capital.

National laws and rules need to be harmonized with those of other countries, if Sweden is to retain the prominent position it has gained because its people, companies and institutions have quickly embraced the opportunities of the new era. Harmonization is especially important in the tax field. The competitiveness of Swedish service companies must not be hampered by tax rules that are less favorable than in other countries. People distinguish less and less between work and leisure. As a result, taxes that primarily affect individuals also have a restraining effect on companies if they deviate from those of other countries. This may apply to the valuation of work-related benefits for tax purposes, value-added taxation of domestic services, labor laws etc.

If Sweden is to hold its own in global competition, it is necessary for as many of its people as possible to have the opportunity to participate in and influence changes. It is obviously also a democratic requirement that everyone should have a chance to share in progress. We believe that Swedish political authorities should consider the possibility of subsidizing computers and broadband in homes, with the ambition that everyone should have access to the Internet. This would also give our country's citizens new opportunities to participate in the democratic process.

We would gain a more effective society, lower production costs and higher quality of life in many respects. By means of the future scenarios that we present in this report, we want to show, among other things, that the network economy can save time and money and make goods and services cheaper. In other words, it will have an inflation-restraining effect. Swedish service companies will enjoy a rapidly growing, demanding domestic market. Intensive, far-reaching competition, in turn, will stimulate new business ventures.

Our projection of future trends related to labor demonstrates that it is possible to identify more efficient methods for performing our paid work. We will work in networks and projects. Sometimes we will be the client and sometimes the contractor. We will improve our knowledge and educate ourselves more easily and inexpensively. Our future projections also show that technology will enable many people to work at home or in its vicinity. This will affect urbanization. Perhaps it will end the monopoly of cities and towns on proximity to opportunities. Services and experiences will become more accessible via the Internet. Under any circumstances, companies will emerge in substantially larger zones around major cities. This will make it possible to reduce local work-related travel in and around major cities. Meanwhile, as a result of globalization, travel across and between continents will increase. Especially in that context, the boundary between work and

leisure will become less sharp.

The existence of a large number of new companies in the service sector will provide diversity and create freedom of choice for people. Among other things, this will offset the ability of major corporations to monopolize markets. It has been said that this kind of monopoly, together with the tax system, has made the prices of services and goods in Sweden higher than in other countries. The diversity that new service companies will create may shift power from entrepreneurs and employers toward consumers and employees. New technology creates the preconditions for greater interactivity.

Household work can be made more efficient with the aid of "intelligent" homes. In the projection of future trends that we call "Experiences," we point to new opportunities in the fields of entertainment and culture. There, too, a need for new entrepreneurship will arise. Among other things, as individuals we probably need help to navigate through the large variety of choices. On the other hand, to a greater extent than today, we can care for our health at home.

Panel 8 Education and learning

Lifelong learning for everyone is the big challenge for Sweden. This is because we are witnessing more and faster changes, increasing diversity and a more experimentally oriented economy. But this challenge can be met. Information technology will provide new opportunities – if it is adapted to people.

In the future, education and learning will assume different forms, depending on what forces are driving developments. In parts of the world where a few large players drive developments, these players will be able to influence education and learning globally. In this respect, individual countries and groups of countries may find it harder to assert their interests. The same is true in milieus where people act freely and move globally as individual entrepreneurs. What will control developments in these milieus will instead be international standardization and competition. In areas where a large number of players that are geographically close together are driving developments – that is, in regional competition – international standardization will not be self-evident, but will be important for competitive reasons. Here overall national and international interests may find it hard to assert themselves against the regional interest in being competitive. In areas where developments are driven by a few large players without globalization, national interests can more easily control education and learning.

The challenges for Sweden in education and learning are as follows:

- At an overall level, the main challenge is to make lifelong learning available to everyone, to ensure that it contributes to the competitiveness of the business sector and, for the individual, that it is "seamless" and flexible in time and space.
- In childhood and youth education, the challenges are to ensure that this education gives everyone a sufficient basis for continued lifelong learning, that schools are good workplaces for pupils and teachers and that each pupil receives his/her appropriate individual platform for continued lifelong learning.
- Post-secondary education must combine breadth and depth, while reconciling personal integrity and autonomy in terms of scholarly and democratic values with the other demands of stakeholders. The individual player – for example,

an institution of learning – must be competitive in recruitment of students, employees and resources. The educational system must, within broad limits, be able to flexibly provide each individual with the education he/she is asking for.

- Continued lifelong learning must contribute to a competitive labor market and to people's involvement in social issues, to the competitiveness of companies and public sector organizations and to the career and personal happiness of the individual.

To meet these challenges, the panel would like to mention the following efforts and areas of effort:

For lifelong learning as a whole, the challenges can be met by:

- informing and motivating people
- making new technology more accessible
- ensuring that there is both enough time and money for lifelong learning
- relaxing rules and regulations that hamper mobility and "seamlessness" for the individual.

The challenges in the childhood and youth education system will require a very large concerted effort. Elements of this effort may be to:

- make values and objectives come alive
- create clear leadership and an attractive working environment in the schools
- build networks between schools
- take advantage of IT in pedagogical development and for disseminating information
- to a greater extent, compare and standardize schools internationally
- use alternative forms of operation as a positive force and improve the expertise of the public sector in its purchaser role.

The challenges in the higher education system can be met by:

- improving international collaboration
- persuading institutions of higher learning to carve out their own distinct images, compete and work together
- expanding access to higher education
- monitoring critical research tasks
- testing new ways of organizing a higher education institution
- using modern technology to develop both critical and constructive thinking
- increasing the education premium, i.e. salary differences based on formal education
- monitoring the resource situation in the higher education system: the introduction of student fees may need to be considered.

The challenges of continued lifelong learning can be met by:

- giving lifelong learning a clear strategic focus
- developing know-how about organizational learning and the transfer of tacit knowledge
- creating an adult education system for the IT age.

In certain areas, Sweden may very well assume an internationally leading position. This applies, for example, to giving everyone in the childhood and youth education system a basis for continued lifelong learning. It applies to pedagogical development work using "IT with a human face." It also applies to development work in such areas as efforts by universities to create more distinct public images, labor market-related lifelong learning, organizational learning and tacit knowledge as well as adult education in the IT society.

7 Technology Foresight just the beginning...

Why Technology Foresight?

The American futurologist Peter Schwarz is among the world's leading designers of future scenarios about how we live, communicate, work, consume or amuse ourselves. A very optimistic image is apparent in his most recent scenarios. Among other things, they assert that large portions of the world will experience 25 very good years, characterized by greater freedom, better environment and increased material welfare.

New technological advances are the most important driving force behind growth and renewal in such fields as information technology, energy supply and genetic engineering that are predicted to provide increasing quality of life. According to these scenarios, in 2020 we will experience "quantum computing," buy the first commercial nanoproducts and be able to treat one third of humanity's 4,000 genetic diseases. The point of these technological predictions is that they draw attention to the potential for improving the quality of life that new technology can deliver.

A number of elements of development work reinforce the need for long-term technology assessments. To an increasing extent, new technology is selectable and adaptable – in other words, there is no optimal solution. This applies, for example, to IT, which has the paradoxical characteristic of simultaneously becoming more complex, robust and generally adaptable – something that, for traditional technology, sounds like an impossible combination. One consequence is that technology implies substantial freedom of choice. That freedom of choice provides major opportunities for companies and organizations capable of spotting new opportunities, embracing new technology and integrating technology into the other competencies of their operations.

Technological advances are behind much of the world's growth and renewal, but globalization is perhaps the most important driving force. During the foreseeable future it will dominate the changes in our living conditions. Meanwhile, changes in attitudes and values are essential for social and technological development. It is also becoming increasingly important for all technologic development to take ethical issues into account.

In a way, Sweden faces greater challenges than many of our large trading partners. Countries and regions with small populations and an open economy are always heavily dependent on foreign trade. This gives them strength, flexibility and major opportunities to identify new markets and achieve good economic growth, but it also creates vulnerability.

One way to increase the chances of maximizing one's advantages and minimizing one's vulnerability is to predict the future as accurately as possible. This has always been the case. Princes have surrounded themselves with fortunetellers and astrologers. Modern companies and governments engage the services of global analysts, think tanks and forecasting institutes.

Ordinary people, too, have always speculated about the future. A large proportion of science fiction deals with how technological and scientific development may conceivably affect our future. Science fiction has often also been used to elucidate the consequences of contemporary trends. Examples of this are H.G. Wells'

The Time Machine, George Orwell's *1984* and Harry Martinsson's *Aniara*.

More systematic future studies have existed since the 1950s. Various institutes have been founded in order to study future scenarios. Governments, organizations and companies are continuously conducted a large number of studies of the future in order to elucidate developments in various sectors.

In recent years, a number of countries have carried out national studies of the future. Japan publishes a study with a 30-year horizon that it updates every five years. Great Britain published its Technology Foresight in 1995. Germany, Australia, New Zealand, the Netherlands, Hungary and Ireland are among the other countries that have carried out this type of studies.

A Swedish preliminary study completed in 1997 stated that a Sweden Technology Foresight could be expected to provide valuable contributions to long-term planning for companies and organizations.

During the spring of 1998, a decision was thus made to carry out *Teknisk Framsyn* (Swedish Technology Foresight) as a national project. Its purpose would be to engage many of the players in Sweden's "knowledge society" in a discussion of the best ways to promote a long-term interplay between technological, economic, institutional and social processes.

The project has been run by the Royal Swedish Academy of Engineering Sciences (IVA), the Swedish National Board for Industrial and Technical Development (NUTEK), the Swedish Foundation for Strategic Research and the Federation of Swedish Industries. It has been implemented with support from the Swedish government and in close collaboration with companies, public agencies and other interested parties.

The objective of Swedish Technology Foresight has been to strengthen a futures-oriented approach in companies and organizations and to identify and prioritize areas of expertise with potential for growth and renewal in Sweden.

Technology Foresight has therefore attempted to convey insights and credible images of the future that may form the basis for a discussion of trends in Swedish society and in the business sector, and on how Sweden can use technology in the service of humanity.

Hindsight

"The telephone is a fantastic invention – I am sure that every city will get one."

This quotation illustrates the difficulty of foreseeing the full use and consequences of new technology and new ideas.

Swedish Technology Foresight carried out a separate study of earlier attempts at predicting the future, *Teknisk baksyn* (Technology Hindsight).

This study discusses various difficulties and sources of errors that should be borne in mind. Among the factors contributing to the failure of previous predictions, it found:

1. The belief that new technology will replace existing technology, and that this will happen relatively fast. In reality, competing technologies often co-exist over a rather long period.
2. The belief that new technology will only solve old problems and supplement existing technological systems. Instead, new technology often lays the groundwork for entirely new systems.
3. The belief that new technology will function as a panacea for various social problems.
4. The difficulty of seeing important links between different fields of technology

in cases where this combination of fields is precisely what will offer major developmental opportunities.

5. That those who have tried to predict the future have become bogged down in the actual technology and thus neglected the economic aspects.
6. That people have been prisoners of the spirit of their times (or *Zeitgeist*), believing that the big issues of today will also be the big issues of tomorrow.
7. That rational economic considerations are not the only factors behind the choice of a new technology. Seemingly irrational considerations often determine such choices.
8. That the information on which future studies are based has often been insufficient. A great deal of technological development takes place secretly, mainly in the military sector.

No method in the world can provide a sure image of how Sweden will look in 15-20 years. The only thing that can be predicted with certainty is that unexpected things will happen. Technological development is not linear and predictable, any more than political and social development.

But the difficulties of foreseeing the basic outlines of the future should not be exaggerated either. Every generation perceives itself as living in an age of major changes. Perhaps the generation of August Strindberg (1849-1912) experienced larger actual changes than today's Swedes. It is quite certain that the Sweden of 2020 will not have changed to the point of being unrecognizable. A large proportion of the infrastructure – such as buildings and roads – are renewed over longer periods than 20 years. The same is true of many technological systems. Most of the Swedes who will be alive in 2020 are already adults, and many developments over the next 20 years will be based on technological advances that are already known.

Swedish Technology Foresight has deliberately chosen to ignore pure disaster scenarios. We cannot rule out that over the next 20 years, our society may be subjected to wars and blockades. Nor can we predict terrorist actions, devastating epidemics, the collapse of the food or energy supply system or large-scale disruptions in the world economy. The mere act of worrying about the possibility of such events may be of great significance to national development, for example in the form of military build-ups or trade barriers of various kinds. In this respect, Swedish Technology Foresight is optimistic – perhaps excessively colored by its own *Zeitgeist*.

In this context, it is important to be aware that Swedish Technology Foresight has been based on different assumptions and has had a different objective from other comparable studies. The project is uniquely Swedish. Instead of saying, "This is how it will be!" Swedish Technology Foresight has assumed that there is no need to be familiar with the minutiae of the future in order to prepare for it. We can go a long way by analyzing the main features of likely developments. The important thing is to have enough knowledge to dare realize that we cannot know how it will turn out, to dare to act without being completely sure of the direction of the journey and, based on the right knowledge, to constantly be prepared to reassess our decisions.

This is how Technology Foresight was implemented

The idea of carrying out a Technology Foresight project in Sweden emerged in the mid-1990s under the pressure of rapid technological and political change around us. Technologically oriented future studies had been conducted in Sweden during the 1970s and even earlier, but during the 1980s such studies, if at all, were only pursued inside private organizations. Perhaps the difficulties that had recently affected the Swedish national economy contributed to the increased interest during

the 1990s.

There were several conceivable foreign models for Sweden's Technology Foresight project. The British version of Technology Foresight, which was presented at IVA in April 1996, was an important source of inspiration. The Federation of Swedish Industries analyzed the effect of relevant European studies and decided to initiate a Swedish study. IVA and NUTEK carried out a joint preliminary study about international experiences and on the preconditions and interest in Sweden for carrying out a corresponding project. This initiative evoked interest in many quarters.

After further preparation in 1997, the four organizations behind the study – IVA, NUTEK, the Federation of Industries and the Foundation for Strategic Research – formed a committee to evaluate the possibility of carrying out a Technology Foresight project. Unlike most studies in other countries, Swedish Technology Foresight was not carried out on behalf of the government, although it has enjoyed strong government interest and support.

To direct the Swedish Technology Foresight project, in 1998 the four organizations behind the study formed a Steering Committee with the following members:
Arne Wittlöv, Executive Vice President, AB Volvo (Chairman)
Gunnel Färm, Director-General, Swedish Council for Work Life Research
Christer Heinegård, Director, Technical R&D, NUTEK
Professor Ingvar Lindgren, Swedish Foundation for Strategic Research
Camilla Modéer, Research, Education and Development Program, Federation of Swedish Industries
Professor Kurt Östlund, President, IVA
Enrico Deiaco, Secretary to the Academy, IVA, was appointed Secretary of the Steering Committee.
A project office was attached to the Steering Committee to administer the project. Lennart Lübeck, Chairman of the Swedish Space Corporation, was appointed Program Manager. Others working in the project office were Enrico Deiaco (IVA), Lennart Elg (NUTEK), Bengt Mölleryd (IVA) and Lennart Björn, Project Controller.

The four organizations behind the study also established an Advisory Committee in order to broaden the range of organizations involved in the Technology Foresight process. Some 30 interest organizations have been represented in this committee. The task of the Advisory Committee has been to ensure that important interested parties in Sweden have been integrated into the process, as well as to suggest names of possible panel participants. Another task of the Committee has been to create involvement and generate support for the Technology Foresight project in their respective organizations, disseminate its findings and advise the expert panels on their work. In addition, an Evaluation Committee was established and entrusted with continuously following up and evaluating the implementation of the project.

The work of the project was mainly carried out within the eight expert panels. In each panel, a chairperson and about 15 other participants were appointed. Each panel engaged its own project manager, who worked in this capacity at least half-time. The panels were created and staffed by the Steering Committee after thorough deliberations on the delimitation of their subject areas and their composition. Among other things, the Steering Committee examined how comparable foreign studies had been implemented and what lessons had been learned.

The Steering Committee chose to create a limited number of panels, each with a broad-based composition and a broadly defined field, well aware that because of this, no complete coverage of the technology would be possible either. The division into panel subject areas was made on the basis of need and user perspectives, not fields of technology.

No	Panel	Chairperson	Project Manager
1	Health, medicine and care	Leni Björklund	Cecilia Warrol
2	Biological natural resources	Per Ove Werling	Monika Carlsson Ulin
3	Society's infrastructure	Ulrika Francke	Jan Parmeby
4	Production systems	Bengt Palmér	Arne Otteblad
5	Information and communications systems	Ulf J. Johansson	Cecilia Sjöberg
6	Materials and material flows in the community	Gunilla Jönson	Kerstin Lekander
7	Service industries	Rolf Skoglund	Charlotta Eiborn
8	Education and learning	Clas Wahlbin	Börje Svensson

A total of 130 people sat on the eight panels. By means of seminars, conferences etc., a few hundred additional people participated. The work of the panels began with a kick-off conference in January 1999 and ended one year later. A joint conference for coordination of their work took place in August 1999.

It was recommended to the panels that, within a firmly fixed timetable, they should follow a given methodology whose point of departure was a project plan based on the lessons of Technology Foresights in other countries. The Steering Committee also asked the panels to take into account certain lateral, multidisciplinary themes, for example environmental and energy aspects, economy and market, attitudes and values. Within their project plans, the panels were then given great freedom to define and prioritize their tasks.

By and large, the panels followed the project plan. First they carried out an inventory of a large number of subject areas which they believed would prove to be of decisive importance to society in their respective sphere of responsibility. After thorough discussions, they grouped these under various themes. They selected a limited number key areas for more detailed analysis. The structure of the final phase of their work varied between panels.

The panels had the option of forming subgroups and, as needed, outsourcing assignments in order to compile documentation for their work.

As a form of back-up for their work, during the spring of 1999 the project, together with consultants from Sweden's Defense Research Establishment (FOA), worked out four future scenarios. These were based on different assumptions about the role of geographic proximity in development, and about whether development would be characterized by relatively few or relatively many players. The panels used these scenarios to varying degrees in their work.

The eight panel reports were completed in draft form late in November 1999, and in final form in January 2000. A number of highly qualified referees – Bo Berggren, Lars Bergman, Kerstin Fredga, Kristoffer Hallén, Lars Ilshammar, Arne Kaijser, Anders Lindström, Peter Nygårds, Maria Stenström, Björn Sällström and Karl Johan Åström – were asked to read the panel reports and provide overall opinions as background material for the synthesis report.

The Swedish Technology Foresight project was implemented in a very open way. Among other things, the drafts of the panel reports were successively posted on Technology Foresight's web site (*www.tekniskframsyn.nu*) and all interested individuals were invited to comment on the drafts.

The results of Technology Foresight were presented at a final conference in March 2000. During the spring and autumn of 2000, Technology Foresight will also be presented at a number of meetings, including a series of regional confer-

ences around Sweden.

This synthesis report was written on behalf of the Steering Committee, and under its supervision, by Leif Magnusson (EnerGia), Stefan Zenker (Swedish Space Corporation), Olle Rossander (independent consultant) and Benny Kullinger (Ord & Vetande).

The project was run within a cost ceiling of SEK 34 million. The financiers were the Swedish Foundation for Strategic Research (SEK 17 M), NUTEK (SEK 10 M) and the Swedish government (SEK 7 M).

The process moves ahead...

Swedish Technology Foresight is an ongoing process, in which the presentation of this report on March 28, 2000 only marks the end point of an introductory phase.

The objective of Technology Foresight has thus been to use technological development as a point of departure for stimulating a discussion of the future development of Swedish society and business. Among other things, Technology Foresight has identified fields of expertise with potential for growth and renewal in Sweden, for the purpose of strengthening the futures-oriented work of companies and organizations. This is not something that can be done on a single occasion and then be regarded as finished.

The Technology Foresight project must be carried forward in various ways, and in various forms.

Dissemination of findings

During the spring and autumn of 2000, Technology Foresight is organizing regional conferences at many locations in Sweden. Participants in the various panels will present the results of their work. In the best case, this may lead to the beginning of local "foresight activities," perhaps with Technology Foresight as a model. A number of organizations and companies have also invited project participants to present the project's findings at various events and gatherings during the year.

The findings of Technology Foresight are also being disseminated via the four organizations behind the project, through their human networks. All the project reports are available via the Internet on Technology Foresight's web site, *www.tekniskframsyn.nu* (mainly in Swedish), and are also available in printed form.

The most important method of all for disseminating the thoughts and findings of the Swedish Technology Foresight project, however, is the informal conversations and discussions conducted by the people who participated in its work, or by others who have come into contact with Technology Foresight in some other way.

Broadening and intensifying the process

The Swedish Technology Foresight project chose to work with relatively few panels and thus with broad subject areas. All panels were also given the specific assignment of weighing in and taking into special account a number of interdisciplinary themes, among them environmental and energy issues.

Within these limits, the panels made their own prioritizations. A prioritization means that certain subjects were highlighted while others, which are not thereby considered unimportant, were treated in a more summary way.

Nor has Technology Foresight conducted in-depth studies in its various fields. After all, its purpose was not to carry out research planning. The panel reports will provide a starting point for a continued process, which will include more in-depth

analyses of Sweden's areas of expertise, improvement needs, consequences for various fields of technology and science, strengths and weaknesses, threats and opportunities – nationally and regionally.

The shape of these in-depth and follow-up studies will be up to the players in the Swedish business sector and public sector to decide.

Recurring Technology Foresights?

In Sweden we should carry out a comprehensive national Technology Foresight fairly regularly, as a number of other countries do. In general, such a process should have the same purpose as the current one, but we should naturally be open to changes in our working methods. Among other things, all the lessons – positive and negative – from the current Technology Foresight should obviously be taken into account, along with the lessons continuously being learned from similar processes in other countries. This may apply, for example, to such fundamental issues as how much time to budget completion and how best to utilize this time, especially considering that the most insightful people tend to have little time.

The interval between recurring Technology Foresights at the national level should probably not be much shorter than five years, but perhaps not so much longer either.

Evaluation

The lessons from the implementation of Swedish Technology Foresight have been followed up on a continuous basis by an Evaluation Committee, which will report its observations and conclusions to the four organizations that ran the project. This evaluation will focus on the actual process, not the findings of the project's work.