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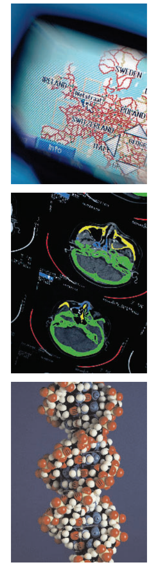

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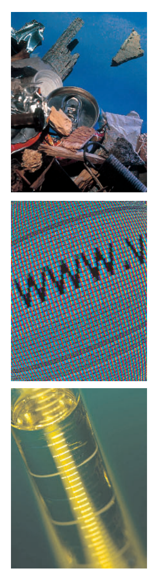
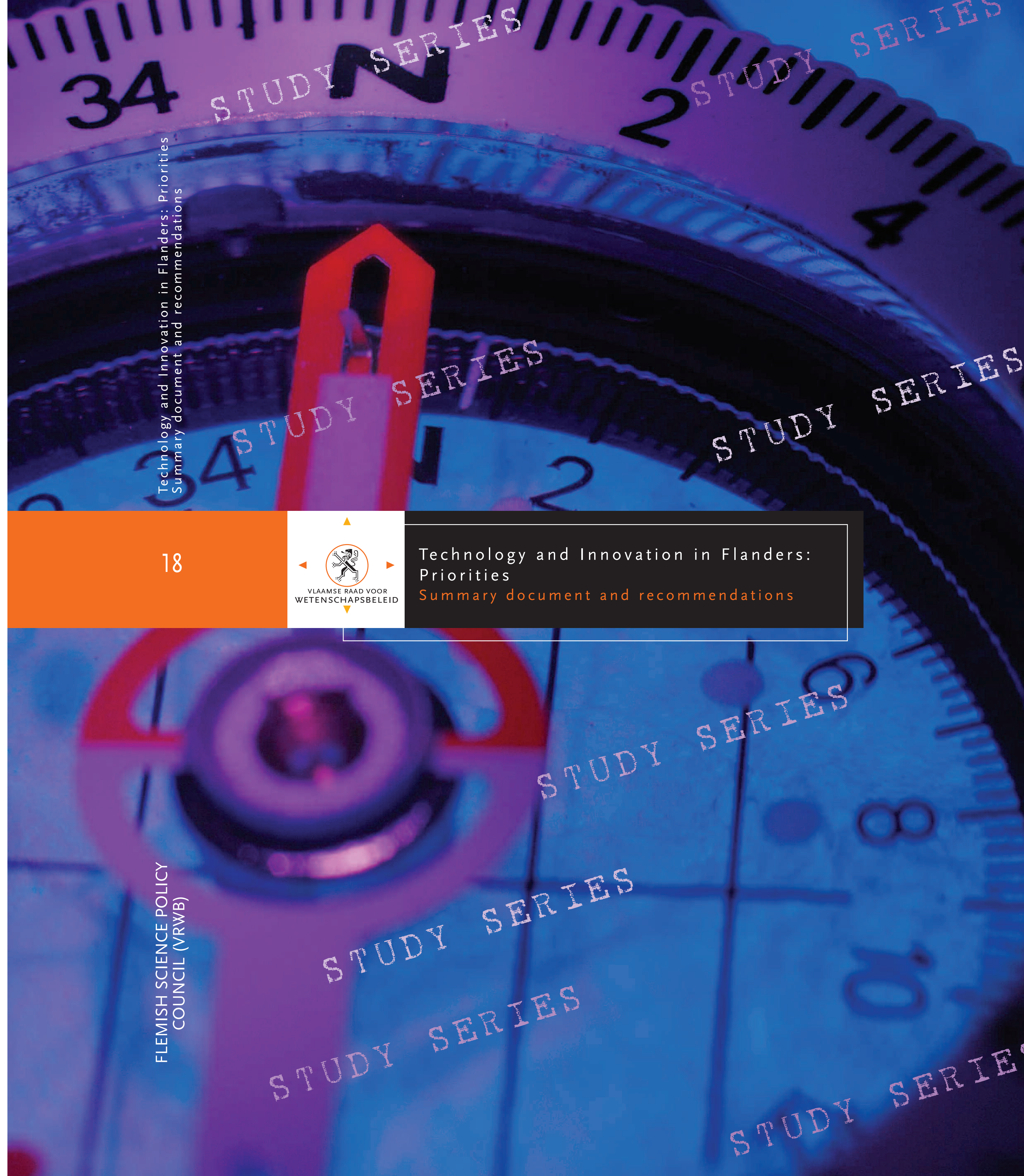


Technology and Innovation in Flanders: Priorities
Summary document and recommendations

FLEMISH SCIENCE POLICY COUNCIL (VRWB)



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Technology and Innovation in Flanders: Priorities

Summary document and recommendations

TECHNOLOGY AND INNOVATION IN FLANDERS: PRIORITIES

SUMMARY DOCUMENT AND RECOMMENDATIONS

Flemish Science Policy Council
in collaboration with the research division of Incentim, K.U.Leuven

FOREWORD

Knowledge is increasingly recognised as a factor that can boost the competitiveness of regions and countries. Indeed, knowledge and innovation are the key factors in ensuring that Flanders retains its prosperity and welfare in the future. Small regions like Flanders need to develop a strategic vision if they are to make any mark on the international scene. They must resist any fragmentation of their limited resources. The government, companies and knowledge institutions must join forces to create focus and critical mass in strategic areas that strengthen Flanders' competitive position and offer potentially substantial social benefits. It is important, therefore, that we concentrate on those areas in which we can excel internationally, or at least at European level, and in which we have a comparative advantage.

The choice of these areas must be guided on the one hand by concrete social and socio-economic needs and on the other by first-rate research groups that have made it to the top internationally. It is in the field of tension between the two that foresight studies are conducted. Technology foresight studies can reveal options for orienting scientific research and technological development while at the same time creating a decision-supporting framework for regional innovation policy and its relationship with regional economic developments.

I see foresight studies as an excellent means of linking science and technology with innovation in industry and society. After all, innovation is a complex process involving many different players. To create a framework in which new applications can lead to economic growth and social development, three types of innovation need to be taken into account: 'product and service innovation', 'process innovation' and 'structural innovation' leading to a radical overhaul of existing socio-economic structures. Such 'structural' or 'socio-economic' innovation is largely the responsibility of government: it is up to the government to create a favourable climate for enhancing Flanders' innovative strength. As experience in the Scandinavian countries shows, only where all three types of innovation are present at the same time and working in harmony can innovation generate economic growth and employment.

Launched in early 2005, this research project undertaken by the Flemish Science Policy Council (VRWB) examines the strategic choices that need to be made regarding technology and innovation in order to secure Flanders' future prosperity and welfare. This project was preceded by a long gestation process. As early as 1986, when the VRWB was launched, the then President of the Flemish government Gaston Geens saw foresight studies underpinned by a long-term vision as a key element in the VRWB's work. Since then the VRWB, in collaboration with Incentim K.U.Leuven, has built up considerable experience in organising and managing technology foresight projects. A methodological framework for science and technology foresight studies has been developed and tested out on two sectors of importance to the Flemish economy, namely chemicals and food.

This foresight study - a collaboration between 130 technical and economic experts from industry and knowledge institutions - identifies 30 priorities and 15 preconditions within six clusters of strategic importance to Flanders. The findings of the study are set out in this report, which also makes a number of recommendations. The VRWB's principle aim is to provide a reference framework on innovation-related activities in Flanders for all stakeholders. If we are to enhance Flanders' innovative strength, simultaneous and coordinated attention needs to be paid to both priorities (product and process innovation) and critical preconditions (structural innovation).

The Foresight Steering Committee, which I chaired, was responsible for overseeing the project while the VRWB project team prepared and carried out the actual study. Scientific support was provided by Incentim, K.U.Leuven. The entire prioritisation process is described in the second volume of this series of studies entitled "Technology and Innovation in Flanders: Priorities – Prioritisation Process and Findings" (Smits E. et al., 2006).

I would like to congratulate the VRWB's staff, led by Elisabeth Monard and Danielle Raspoet, for this wonderful project and for ensuring that the whole process ran smoothly. My sincerest thanks go to Professor Koenraad Debackere, Incentim K.U.Leuven, the Foresight Steering Committee, the Policy Research Centre for R&D Statistics, the Policy Research Centre for Entrepreneurship, Enterprises and Innovation, as well as all the experts who offered their assistance with the project.

Karel Vinck
President
Flemish Science Policy Council

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INHOUD

INHOUD

EXECUTIVE SUMMARY

In early 2005, the Flemish Science Policy Council (VRWB) launched a research project into strategic decisions on technology and innovation with a view to ensuring Flanders' future prosperity and welfare. Insights into the current situation regarding scientific research, technological development, innovation and economic activity in Flanders, and into key and relevant trends in the fields of research and innovation, as analysed in international foresight studies, have made it possible to set priorities via a broad consultation process.

Based on how well the technical and economic strengths of Flanders[1] match up with the technical and economic trends identified in a recent European foresight study[2], the Steering Committee selected the following six strategic clusters:

Strategic cluster 1: Transport-Logistics-Services-Supply Chain Management
Strategic cluster 2: ICT and Services in Healthcare
Strategic cluster 3: Healthcare-Food-Prevention and Treatment
Strategic cluster 4: New Materials-Nanotechnology-Manufacturing Industry
Strategic cluster 5: ICT for Socio-economic Innovation
Strategic cluster 6: Energy and Environment for Services and Manufacturing Industry

The prioritisation is the result of an interactive and iterative consultation process involving 130 technical and economic experts divided into six panels, one for each strategic cluster. Working on the basis of an international trend analysis, the expert panels started with around 160 technical and economic developments, from which they selected 30 priorities for Flanders based on a positioning and delphi analysis (see Table 1 for a summary of the priorities). In addition, 15 preconditions were listed for the purpose of increasing Flanders' innovative strength.

The 30 priorities and 15 preconditions within the six strategic clusters were validated by the Foresight Steering Committee. Then, on 22 June 2006, the Council discussed the findings of the foresight study in detail and drew up recommendations. The Council considers prioritisation of technology and innovation to be a reference framework for all stakeholders in Flanders: the government, industry and knowledge institutions.

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1 Based on data of the Policy Research Centre for R&D Statistics at the Policy Research Centre for Entrepreneurship, Enterprises and Innovation
2 Key Technologies Cluster Approach, European Commission, 2005 http:// www.cordis.lu/foresight/kte_expert_group_2005.htm

A more systematic approach to foresight studies will create a policy framework for Flemish policymakers that can support and motivate strategic policy decisions on technology and innovation. The foresight study is a lively, dynamic process with a broad support base that dovetails nicely with European initiatives. With this study, the VRWB has succeeded in getting all of the stakeholders significantly involved in innovation-related activities, and therefore in the future of Flanders.

Table 1: Priorities for six strategic clusters in Flanders

Six strategic clusters for Flanders	Priorities for Flanders
Strategic cluster 1: Transport - Logistics - Services - Supply Chain Management	> Intermodal transport > Intelligent supply chain management > Intelligent transport systems > Virtual design and production
Strategic cluster 2: ICT and Services in Healthcare	> E-health with the emphasis on the electronic medical file and the integration of multiple healthcare information systems > Innovative healthcare services and products for (home-based) healthcare > Medical imaging and processing > Multidisciplinarity: bioinformatics, chemoinformatics, neuroinformatics
Strategic cluster 3: Healthcare: Prevention and Treatment	> Molecular diagnostics and biomarkers > Preventive and therapeutic vaccines > Cell therapy > Molecular biological research for targeted diagnosis and therapy > Translational medicine > Interdisciplinarity with applications in healthcare
Food and Agriculture	> Relationship between food and health > Agricultural biotechnology > Industrial biotechnology
Strategic cluster 4: New Materials - Nanotechnology - Manufacturing Industry	> Structured micro- and nanomaterials > Materials for nanoelectronics, micro-optics, photonics, micro-mechanics, etc. > Unique composites > Materials and material systems that interact with the environment > Enabling technologies
Strategic cluster 5: ICT for Socio-economic Innovation	> Advanced networks: broadband, mobile, wireless > Properties/criteria of advanced networks: ambient intelligence, context awareness, security > Converging technologies and application development > E-applications: e-health and e-society
Strategic cluster 6: Energy and Environment for Services and Manufacturing Industry	> Efficient use of energy in industry and buildings > Smart grids > Power generation > Sustainability of production processes and products

PART 1
PRIORITIES FOR SIX STRATEGIC CLUSTERS IN FLANDERS

STRATEGIC CLUSTER 1

TRANSPORT-LOGISTICS-SERVICES-SUPPLY CHAIN MANAGEMENT

The transport and logistics industry is set to develop significantly under the influence of a broad array of technologies. The transport systems of the future must meet the rising quantitative needs and changing qualitative demands of users, in such areas as functionality, quality, safety, reliability, sustainability and environmental impact. For Flanders, implementing an effective and efficient intermodal transport model, further expanding intelligent supply chain management techniques and developing and creating intelligent transport systems are definite priorities for the coming years.
By making greater use of virtual design and production techniques as it works towards these priorities, Flanders can play a leading role in these fields.

Intermodal transport

To increase the intermodality and interoperability of transport networks, rational and powerful management and information systems need to be introduced and innovative terminals created which will enable the integrated development of air, sea, inland waterway, rail and road transport. Eliminating bottlenecks that hamper the interconnectivity and interoperability of infrastructure, vehicles, access modes, payment methods and information, will allow transport time to be reduced. Developing air, sea, inland waterway, rail and road transport on an integrated, intermodal basis will also make it possible to boost transport speed and frequency, improve reliability for users and build in more flexibility.

Intelligent supply chain management (focusing on and integrating the entire chain)

Organising and optimally managing an intelligent supply chain requires coherent decision-making for all processes in the supply chain, from production right through to the organisation of the logistical chain. The ultimate aim should be a truly integrated system of enterprise management involving cooperation across organisational boundaries (e.g. through networks). Advanced logistical information systems, such as enterprise resource planning (ERP) solutions (e.g. forecasting, scheduling, supply network planning), can be used to synchronise goods and data flows and ultimately to automate, integrate and optimise operating processes. ICT innovations and the constant search for and application of process innovations are vital for optimising companies' overall supply chain management.

The intelligence of supply chain management will increase further under the influence of various factors, including the development and implementation of the following elements and concepts: CRM packages with data mining, collaborative extended supply chain, voice picking, virtual manufacturing, extensive automation (robotics), application of lean production or lean manufacturing principles, cost-to-serve, material requirements planning (MRP), warehouse management systems (WMS), transport management systems (TMS) and advanced planning & scheduling (APS), mobile resource management, etc.

Continually enhancing the intelligence of supply chain management is arguably more important for Flanders than for other regions due to both its high population density and the major role already played there by the logistics sector. Indeed, logistics fulfils a highly strategic function for industrial enterprises based in Flanders.

Intelligent transport systems (flexible, adaptable, innovative transport networks)

New telematics applications derived from soft/hardware and ICT innovations will impact steadily on vehicle intelligence over the coming decades. Through direct coupling with vehicle intelligence, the intelligence of transport systems and networks should be enhanced with the introduction of the latest IT and ICT technologies. The use of Intelligent Transport Systems architecture, the introduction of Global Systems for Telematics (GST), the expansion of GPS and GIS support and the use of digital information systems via mobile and wireless (inter)networks should result in a more intelligent and flexible transport infrastructure and more efficient management of transport flows. Transport speed could eventually start to increase again as a result. In time, we also expect to see an extensive integration with information and communication networks, which will also enable corrective action to be taken (Guided Vehicle Navigation, global positioning, built-in (mobile) ICT systems, use of speech technologies and user-friendly (multimodal, 3D) interfaces and displays).

Virtual design and production (products, vehicles, (operating) processes and systems)

Virtual design and production of products makes it possible to analyse and optimise the manufacturability, assemblability and design of vehicles and products without the need for physical prototypes. By increasing their use of advanced systems such as simulation, measuring, monitoring and testing techniques, companies can speed up the product design and development process (cf. "enabling technologies" from strategic cluster 4 "New Materials – Nanotechnology - Manufacturing Industry"). These computer-based design and simulation techniques can also be used to very good effect in developing new transport and transportation systems and even in designing or redesigning operating processes within the entire supply chain.

Examples of such intelligent design techniques include virtual manufacturing, for testing manufacturability, and virtual prototyping, for testing product or system properties (e.g. 3D-CAD, Graphical Data Processing). The use of computer-aided design and computer-aided manufacturing (CAD/CAM) tools will become standard practice in product design and production. Product lifecycle management (PLM) solutions will make it possible to integrate all kinds of information and thereby to limit throughput time, streamline the production process and cut production costs. In addition, increased automation - in this case robotics - will have a major impact on the production process and production organisation.

It should be noted that the vehicle construction sector currently plays a major role in the Flemish economy. To guarantee the long-term survival of the sector in Flanders, a number of high-tech supporting activities (e.g. virtual manufacturing) must be developed that can be supplied to these companies, in addition to offering them various kinds of valuable supply chain activities which are already being sourced from a variety of different suppliers. The very high added value that these services and activities represent for assembly and manufacturing firms will encourage these companies to continue operating in Flanders in the longer term.

Focal points

Within this strategic cluster, the following focal points for technology and innovation in Flanders were identified, in addition to the priorities:

- Flanders currently has plenty of know-how and expertise on logistics and supply chain management activities. Ensuring that this remains so in the future is critical. A key task for all parties involved (academics, business and industry, government) is the provision of appropriate training programmes and initiatives, so that the latest technologies can be used effectively by properly trained individuals (e.g. drivers, executive staff, IT experts).

- The logistics and transport sectors are particularly competitive, not only at the European level but globally as well. It is therefore important that a number of strategic advantages over other countries and regions be developed and/or safeguarded, if Flanders is to remain a strong logistical player in the long term. We must also try to react fastest to broader European trends and developments.

- The competitive strength of the logistics and transport industry is very heavily influenced by the labour costs of employees in these sectors, many of whom are low-skilled workers. Flanders scores particularly badly in this area, given the high labour costs of employees in the sector.

- The only way that Flemish companies and knowledge institutions can make a difference and retain a competitive edge over other players is by being smarter, developing innovative concepts more intelligently and being quicker on the uptake than their rivals (leaving aside the use of new technologies). The government could play an important catalytic role in this respect.

- At the moment, small SMEs are failing to implement innovative concepts and technologies sufficiently. This is due partly to a lack of resources but also to a lack of knowledge about and insight into inherent opportunities. The government could do more to raise awareness among SMEs so that they pick up more quickly on innovative trends. Failure to do so will jeopardise the long-term survival of these smaller logistics companies. The relatively limited learning and absorption capacity of SMEs when it comes to new technological developments must therefore be a key focal point, both for the enterprises concerned and for the government and knowledge institutions.

STRATEGIC CLUSTER 2

ICT AND SERVICES IN HEALTHCARE

Integrating information and communication technology into healthcare can generate improved quality and more cost-efficient working practices. Recent years have seen a steady progression in 'e-health' applications, with the emphasis on the switch from written to electronic medical files. Integrated care trajectories are supported by an integrated and automated information system - vital in ensuring patient-orientated procedures and more efficient use of resources.

Population ageing is expected to mean more new services in the care sector, made possible by the judicious development and use of ICT platforms. Innovations in home-based care will mean that people can stay in their homes for longer, which in turn may help to curb the rising costs of healthcare.

The digitisation of medical imaging and processing is already a reality. Computer-aided diagnosis is very much on the up, making it possible to analyse vast numbers of medical images. Molecular imaging is a promising technique for the future.

Multidisciplinarity and the integration of knowledge from different information sources and fields is important: the right balance must be struck between in-depth research in specialist fields on the one hand and interdisciplinary research on the other. More specifically, the integration between ICT and biotechnology, ICT and chemistry and ICT and neurosciences is particularly important. This convergence of highly specialised science offers major growth potential as well as opportunities to develop new applications.

E-health with the emphasis on the electronic medical file and the integration of multiple healthcare information systems

Information and communication technology (ICT) is rapidly gaining ground within the healthcare system, particularly for the exchange, management and collection of medical data and information. 'E-health' applications are a broader definition of the ICT-driven services set to transform healthcare. Within e-health, the emphasis lies on the electronic medical file and the integration of multiple healthcare information systems.

ELECTRONIC MEDICAL FILE

The switch from written to electronic medical files is central here. The medical file is defined as a functional and selective collection of relevant administrative, social, psychological and medical data pertaining to a patient and managed by his or her GP. One of its purposes is to ensure that the patient receives the best possible curative and preventive healthcare. An electronic medical file offers a range of functional possibilities that help to ensure the quality of day-to-day care. Besides acting as an aide-mémoire, it also enables information to be consulted and checked, facilitates data integration and continuity, acts as a convenient reference tool and ensures that information is available to doctors and hospitals at the same time. In this respect, using an electronic medical file opens up more possibilities for the doctor: managing and monitoring medication, planning preventive activities at both individual and population level, detection of problems and rapid access to inputted data.

INTEGRATION OF MULTIPLE HEALTHCARE INFORMATION SYSTEMS

The integration of ICT into healthcare is crucial both to improve the quality of service provision and to make working practices more cost-efficient. The potential economic return is huge in what is - due to population ageing - a growth market. Information exchange between patient and healthcare provider and between different healthcare providers takes place via the digital highway. Integrated care trajectories - supported by an integrated and automated information system - make it possible to work in a patient-oriented way and make more efficient use of resources. A wealth of medical information (data, text, images, sound, reports, documents) can be generated, managed and distributed from one integrated system, both within the healthcare organisation (intranet) and outside it (extranet). This requires a standardisation of electronic exchange both inside and outside healthcare institutions.

Achieving top quality and the best possible patient care must be an overall priority. Privacy and security are key - and potentially decisive - aspects in this respect. To ensure that these new applications gain rapid acceptance, research is also needed in the area of legal regulations and legislation.

Innovative healthcare services and products for (home-based) healthcare

Cases of illness and disease are set to increase substantially due to population ageing. A rise in the number of chronic ailments such as diabetes, joint disorders, Alzheimer's, Parkinson's, etc. will spell a further shift from cure to care. This is expected to result in an increase in (new) healthcare services which will be made possible by the judicious development and use of ICT platforms. Innovations in the field of home-based care, such as the creation of intelligent environments, security, domotics, adapted housing, intelligent and socially acceptable robots, personal alarm systems, personalised health advice and other convenience services, mean that people can stay in their homes for longer, which in turn may help to curb the rising costs of healthcare. In fact, the challenge for the future will be to provide not just more care but also better quality care, i.e. care that is effective, safe and accessible to all. The threshold for innovation in the field of (home-based) healthcare is more one of user acceptance than of technology.

Medical imaging and processing

We are seeing a rapid development of multiple medical imaging techniques thanks to the growing possibilities of ICT. The main feature of the next few years will therefore be the mass transition to digital imaging and processing.

COMPUTER-ASSISTED READING, DIAGNOSIS AND THERAPY

The volume of diagnostic images is overwhelming and precious time is lost examining them all in detail. Techniques include three-dimensional imaging, used to gain a more accurate idea of a required radiation treatment, and real-time imaging (simultaneous diagnosis and treatment) which is used to assist minimally invasive surgery. In addition, more and more diagnostic images are being produced as a result of the introduction of screening programmes for common types of cancer. Computer-assisted reading, diagnosis and therapy is very much on the increase.

MOLECULAR AND FUNCTIONAL IMAGING

The ground-breaking techniques of modern molecular biochemistry enable the creation of highly specific contrast media which can be used in very low concentrations to show up previously inaccessible processes. This used to be the exclusive preserve of radioactive tracers, but now a new generation of functional binding molecules are emerging that can be used as tracers. Combining these new contrast media with optimised imaging could prove highly effective in detecting diseases like cancer at a very early stage by means of specific molecular indicators in the body. Hence, the integration of anatomic and functional scans will become a reality, as molecular chemistry and imaging converge. Molecular imaging also holds out the prospect of combining localisation, diagnosis and treatment. Molecular diagnosis and therapy based on a person's individual genetic and current condition is likely to be possible in the future.

The big challenge for medical imaging, and brain imaging in particular, will be data validation and the combination and integration of multiple information sources. Developments are needed based on increased multidisciplinarity in various fields of the neurosciences, clinical sciences, biosciences and statistical analysis.

Multidisciplinarity: informatics applied to biotechnology, chemistry and neurosciences (bioinformatics - chemoinformatics - neuroinformatics)

Multidisciplinarity and the integration of knowledge from different information sources and fields is important: the right balance needs to be struck between in-depth research in specialist fields on the one hand and interdisciplinary research on the other. More specifically, the integration between ICT and biotechnology, ICT and chemistry and ICT and neurosciences is particularly important. This convergence of highly specialised science offers large growth potential as well as opportunities to develop new applications. However, the increase in multidisciplinary research will place high demands on new educational programmes which will need to find the right balance between specialisation and interdisciplinarity across all relevant disciplines and fields.

LARGE-SCALE DATA COLLECTION AND SYSTEM BIOLOGY

Where the integration of biological data and processes is concerned, the emphasis is on large-scale data collection and system biology:

- large-scale data collection: using high-throughput technologies for generating data to clarify the function of genes and gene products and their interactions in complex networks (genomics, proteomics, etc.).

- system biology: multidisciplinary research integrating a broad range of biological data and developing and applying system approaches for understanding and modelling biological processes.

BIOINFORMATICS

21st century medicine will acquire a whole new dimension through the convergence of ICT and biotechnology. The gradual blending of the two disciplines will bring some major innovations in its wake. For example, significant progress is expected to be made in bioinformatics (in combination with functional genomics), leading to an improved understanding of gene and protein functions over the next five to ten years. Further developments of biological algorithms will enable new protein functions to be discovered from DNA and protein databases. Methods for decoding information from DNA patterns will be available for the whole genome. Fast and cheap DNA sequencing methods are also expected to be used to analyse the whole genome including single nucleotide polymorphisms (SNPs), with a view to developing individual therapy concepts. In short, bioinformatics is likely to play a crucial role in the use of large quantities of data derived from proteomics and functional genomics. Besides computing power, another important focal point is analysis/modelling (mathematical and statistical knowledge), which is closely connected with domain knowledge in biotechnology.

CHEMOINFORMATICS

Rational development of medicines using in silico techniques is a new computer-based drug development method. By simulating processes and selecting candidate drugs virtually, results can be achieved more quickly. The affinity of a chemical compound with a biological protein and toxicological profile can also be in-silico screened. In-silico techniques in chemistry and biotechnology speed up the process significantly and make a valuable contribution to drug development, for example.

These techniques are applied at the start of the development trajectory: the faster good candidate drugs (compounds) are selected from the data, the more efficient their subsequent development. This virtual screening procedure saves time and money during the drug development process.

NEUROINFORMATICS

Neuroinformatics will play an increasingly major role in the development of the neurosciences. The brain is an organ of unparalleled complexity, at all levels of its biological organisation, from the molecular to the behavioural. Functions are coupled to dynamic processes, which all too often exceed scientific understanding. Given the complexity of their field, neuroscientists have reached a point where methods based on informatics and the computer sciences have become essential to its further development. This is because neuroscientific data are extremely varied and derived from different levels (biological, chemical, physical, clinical and behavioural) and processes (in space and time, static and dynamic in nature).

Focal points

Within this strategic cluster, the following focal points for technology and innovation in Flanders were identified, in addition to the priorities:

- Healthcare is a federal issue, so the Flemish government can only make recommendations.

- Administration accounts for a significant part of the total cost of healthcare and computerisation could generate a substantial economic return in this area.

- The expansion of ICT in healthcare is not so much linked to technological and economic limitations as to institutions' traditional ideas about investment approach and philosophy. The biggest revolution will be changing the way they work. Obstacles are: a lack of effective privacy, security requirements with respect to electronic medical communication, no economic incentive (the recommending doctor only has costs, no returns), too few clinicians are involved in determining the field of application.

- Restrictive regulations: healthcare has more regulatory requirements than any other sector and these mean that many things cannot be done.

- In-depth knowledge of cognitive neurosciences is essential:
  Robots need to be not only intelligent but also acceptable to older people and patients by being attuned to the individual's cognitive style. Bringing about this technological revolution will require in-depth knowledge of how people interact with computers. Developments in the field of cognitive sciences will play an important role in this respect. Training programmes for IT specialists will therefore need to pay attention to the interaction/interface between users and the ICT service.

STRATEGIC CLUSTER 3

HEALTHCARE - FOOD
PREVENTION AND TREATMENT

Given the ageing society in which we live, technological innovation in healthcare is our number one challenge for the future. Molecular diagnostics will play an increasingly major role. Based on their (epi)genetic profile, it will be possible to tell which individuals are predisposed to which diseases and how those will progress over time. Using biomarkers, which operate at the interface between diagnostics and therapeutics, the most appropriate therapy for the patient can be selected, thereby marking a step towards personalised medicine. Major progress in biotechnology combined with increased knowledge of infectious diseases and immunology will result in the development of new vaccines. Investments in biotechnology platforms with a view to efficient vaccine production will significantly alter the vaccine landscape. Biotechnology developments are also increasingly used for therapeutic purposes. Cell therapy is evolving rapidly. Over the coming decade, the unravelling of the molecular mechanisms responsible for particular disorders will enable earlier and more accurate diagnosis as well as targeted therapy. Translational research, i.e. research conducted at the laboratory-clinic interface, has a particularly important role in improving treatment methods. Modern research in the life sciences is characterised by its increasing scope and complexity. Here too, interdisciplinarity is the watchword. We expect to see increased convergence between biotechnology, nanotechnology, information technology and the cognitive sciences, throwing up an array of potential healthcare applications. A combination of well trained staff and high-quality facilities is essential if we are to maintain the competitive strength of Flanders' research infrastructure.

The relationship between food and health will become increasingly pronounced through interdisciplinary research involving food and medical sciences. In the agriculture and food sector, more genetic modification of crops is expected as a result of expanded knowledge in the fields of genetics and molecular biology. This will enable crops to be developed which are more in line with the needs of consumers and industry, with resistance to disease, productivity and tolerance of extreme environmental factors being the priority. Finally, industrial biotechnology is very much on the rise in terms of applications in the food sector.

HEALTHCARE: PREVENTION AND TREATMENT

Molecular diagnostics and biomarkers

Molecular biological techniques in the field of diagnostics are gaining in importance. Molecular diagnostics focuses on characterisation of the DNA and RNA profile, epigenetic factors (e.g. DNA methylation) and protein markers (expression level, post-translational modification, etc.) of the patient. It will increasingly be possible, based on their (epi)genetic profile, to establish which individuals are predisposed to which illnesses (predictive genetic tests) and how these illnesses will develop. Molecular diagnostics can be used in many areas including clinical chemistry, pathology, microbiology, clinical genetics, hematology, immunology, pharmacogenetics and oncology.

Molecular diagnostics uses a variety of techniques (DNA chip and microarray technology). The method chosen depends very much on the circumstances and the clinical material to be tested. Molecular diagnostics can be used, for example, in detecting and predicting hereditary diseases. Such pathologies are the result either of chromosomal abnormalities, which can be viewed microscopically, or of mutations in the DNA. Molecular diagnostics can also be used for risk-profiling of multi-factor diseases resulting from a complex interaction between genetic predisposition and environmental factors.

Biomarkers operate at the interface between diagnostics and therapeutics. They can be used in the development of drugs, where they make the process both cheaper and more effective. With biomarkers, it will also be possible to detect diseases at an earlier stage and to determine whether a patient will respond well to a particular drug (some drugs not being effective on a small minority of patients). Currently, developing a new drug costs on average 800 million euro and takes around twelve years. Time-consuming and expensive clinical studies are needed to test such factors as the safety and efficacy of a potential drug. In some cases, studies reveal that the potential drug is not effective, or only effective on a small number of patients. Currently, there is no way of telling in the development phase whether a candidate drug is effective.

Biomarkers can bridge this gap, substantially cutting development costs and time. They will also enable the targeted application of therapies, so that a potential drug is administered to those patients on whom it will prove effective. In oncology, for example, most drugs only help a limited number of patients.

With biomarkers, the right therapy for individual patients can be selected, marking a step towards personalised medicine. Biomarkers will also make it possible to detect life-threatening illnesses such as cancer at an earlier stage. The impact of biomarkers on patients, and indirectly on the social security system, will be huge.

Preventive and therapeutic vaccines

Major progress in biotechnology combined with increased knowledge of infectious diseases and immunology will play an important role in the development of new vaccines. The search for new vaccines is geared towards safer and more effective variants without the drawbacks of existing vaccines, as well, of course, as vaccines against illnesses for which none currently exist. By 2015, 80 new preventive vaccines will have been marketed worldwide. The next generation of vaccines are likely to be mostly subunit vaccines, i.e. those based on fragments of a virus or bacterium. Work is also under way on new administration routes for vaccines (nose sprays and skin patches) and on more combination vaccines.

Biotechnology techniques can help in the production of weakened bacteria or virus strains. They also eliminate many of the problems associated with other vaccine production methods: vaccines made from human blood, for example, may contain viruses or prions, whilst those grown in egg white can trigger allergic reactions in patients. Investments in biotechnology platforms with a view to efficient vaccine production will significantly alter the vaccine landscape. Such research is urgently needed for the development of pandemic influenza vaccines. This technology will also be useful for other vaccine developments.

Vaccines against cancer-causing viruses such as the human papilloma virus, which can lead to cervical cancer, would drastically cut the number of cancer cases. The prototype vaccine against cervical cancer is due to be marketed in Europe late this year, paving the way for many other anti-cancer vaccines.
A distinction does however need to be drawn between preventive cancer vaccines and therapeutic cancer vaccines, for which a number of prototypes are currently being developed (lung, breast and skin cancer).

Cell therapy

Biotechnology techniques are being used more and more for therapeutic purposes. More specific, cell therapy is rapidly evolving. Living cells are implanted into a patient to produce natural substances which the patient cannot produce himself.

- Research on embryonic stem cells: Embryonic stem cells are pluripotent, which means that they can differentiate into any of several types of cell. Stem cell research needs to take place within international cooperation programmes that offer the complementary expertise needed for translation into applications. Examples of possible applications are pancreas cells for treating diabetes mellitus.

- Tissue engineering: Major progress is expected in the cultivation of differentiated cells using tissue engineering. Within 10 to 15 years, it will be possible to grow living and dividing cells for a patient on artificially produced biomaterials, using either autologous (i.e. provided by the patient) or allogeneic (i.e. provided by a donor) material. Tissue engineering will be an important alternative to transplantation and artificial implants. To obtain a successful tissue engineering product, a key challenge for the future will be scaling up from lab scale to a clinically usable product.

- Xenotransplantation: This is where animals are used as organ donors. The basic thinking is not new: pigs' heart valves have been used for many years in heart patients. The animals need to be genetically modified in order to prevent organ rejection. The technique of xenotransplantation is still under development.

- Regenerative medicine: This branch of medicine aims to treat diseases characterised by irreparable tissue damage.

Molecular biological research for targeted diagnosis and therapy

Over the next decade, our knowledge of the molecular mechanisms responsible for particular conditions is set to develop exponentially, e.g. through research into cancer, inflammatory diseases (Crohn's, multiple sclerosis, etc.) and brain diseases (Alzheimer's, Parkinson's, dementia, depression, etc.).

The unravelling of these molecular mechanisms will result in ever earlier and more accurate diagnosis and targeted therapy.

Our expanding knowledge of the human genome will also provide information about the individual differences in the metabolic transformation of drugs. The biggest variation in the effect of drugs is caused by the patient's (epi)genetic profile (cf. pharmacogenomics).

A combination of well trained staff and high-quality facilities is vital to safeguard the future competitiveness of research infrastructure in Flanders.

Translational medicine

Scientific research is and will continue to be a constant generator of progress in the treatment of specific conditions. Research at the laboratory-clinic interface, known as translational research, is particularly important in ensuring constant improvements in treatment results. Translation research often takes place while patients are being treated at a clinic.

This type of research requires close daily cooperation between laboratory researchers and clinicians and between researchers working in different fields. This allows the findings of fundamental and basic scientific research to be rapidly incorporated into clinical practice, thereby benefiting patients.

All multidisciplinary approaches with healthcare applications must be encouraged, given the enormous potential they represent. Flanders has a high density of clinics and knowledge centres which can be brought together as part of an interdisciplinary approach. Translational research that allows basic research to converge with clinical practice has a key role to play here.

Interdisciplinarity with applications in healthcare

Modern research in the life sciences is characterised by its increasing scope and complexity. Interdisciplinarity will be the watchword over the coming decade. We expect to see increasing convergence between at least four major technological and scientific disciplines, namely nanotechnology, biotechnology, information technology and cognitive sciences, yielding numerous potential applications in healthcare. Each of these disciplines on its own harbours great potential, but brought together they represent a powerful source of innovation. This convergence of highly specialised science offers potential for growth along with opportunities for developing new healthcare applications. It is important in this respect to encourage these emerging fields on the interface of existing disciplines and to gear them towards tackling major pathologies.

However, the increase in multidisciplinary research will place high demands on new educational and research programmes which will need to find the right balance between specialisation and interdisciplinarity across all relevant disciplines and fields. Initiatives are therefore required to combine work in the field of training and research.

LARGE-SCALE DATA COLLECTION AND SYSTEM BIOLOGY

As regards the integration of biological data and processes, the emphasis is on large-scale data collection and system biology:

- large-scale data collection: using high-throughput technologies for generating data to clarify the function of genes and gene products and their interactions in complex networks (genomics, proteomics, etc.);

- system biology: multidisciplinary research that will integrate a broad range of biological data and develop and apply system approaches for understanding and modelling biological processes.

BIOMEDICAL ENGINEERING

Biomedical engineering as a whole has a vital role to play in implementing new treatments.
The importance of technological development, which typically belongs to the domain of biomedical engineering and which is essential for the scale-up from lab to clinical scale, should not be underestimated. To achieve this, substantial research and the development of technologies are required that enable biomedical engineering products to be manufactured in a reproducible, controlled and large-scale way.

AGRICULTURE AND FOOD

Relationship between food and health

Interdisciplinary research between the food sciences and medical sciences will enhance our understanding of the relationship between food and health. An understanding of dietary factors and habits is key to understanding and combating diet-related diseases and disorders. This includes the development and use of nutrigenomics and system biology and the study of interactions between nutrition and physiological functions. Research in this area could lead to the reformulation of processed foods and the development of new foods and diet foods with a view to improved nutritional value and a more positive impact on health.

Food has been shown to have an ongoing effect on gene expression, and thereby cell and body metabolism. Besides confirming existing orthomolecular knowledge, nutrigenomics research also creates new knowledge. For example, we are gaining more and more insight into the relationship between individual genetic differences and the metabolic effects of foods. Through our increasing knowledge of the human genome, it will be possible to achieve 'personalised nutrition' by adapting diet to particular genetic subgroups and to peoples' individual genetic profile.

In the field of food safety, there has been progress in the development of techniques for detecting harmful substances, micro-organisms, food pathogens and phytopathogens. The trend is towards 'smaller, faster and easier'.

Consumers are becoming increasingly aware of the effect of food on their health. Sales of foods whose composition has been altered, usually to make them healthier, are soaring, with categories including 'functional foods', 'novel foods' and 'nutraceuticals' (foods with potential pharmacological benefits). Probiotics contain a mono- or mixed-culture of micro-organisms that have a beneficial effect on humans (mainly by enhancing the intestinal flora). Better understanding is also needed as to how to adapt nutrition to prevent particular diseases such as colon cancer, brittle bone diseases and cardiovascular diseases.

Agricultural biotechnology

Our expanding knowledge of genetics and molecular biology will lead to more and more targeted interventions in crop development. This should make it possible to select crops with the properties required to meet the needs of consumers and industry, the priority being resistance to disease, productivity and tolerance of extreme environmental factors combined with a reduced environmental impact. This fits in well with the move towards a more sustainable society since plants, including agricultural crops, have a key role to play in the sustainability of our planet. They process greenhouse gases, produce oxygen and medicinal substances and represent a sustainable source of biomass. In the next 10 to 20 years, molecular biologists will gain a fundamental insight into the molecules and mechanisms that guide these processes.

Based on this knowledge, a totally new sort of agriculture will emerge in our part of the world, one geared not so much towards mass food production but rather to small-scale, high-quality production of high value-added agricultural crops. In other words, agriculture will start to move towards high-tech production of quality raw materials. Agricultural crops can be used as an alternative production source for high-quality products such as medically active components and new chemicals and drugs, as well as for renewable materials, efficient biofuels, raw materials for the pharmaceutical industry, textiles sector, food industry and so on.

Industrial biotechnology

Industrial biotechnology is on the up thanks to recently developed genetic techniques. The use of genetically modified organisms in production processes offers major potential in terms of efficiency and sustainability. Industrial biotechnology has applications in the pharmaceutical and food sectors.

Focal points

Within this strategic cluster, the following focal points for technology and innovation in Flanders were identified, in addition to the priorities:

- Healthcare is federal issue, so the Flemish government can only make recommendations.

- Restrictive legislation and regulations: healthcare has more regulatory requirements than any other sector and these mean that many things cannot be done. Examples include: (1) very tough regulations on in vivo experiments for the pharmaceutical and cosmetic industry and (2) very tough regulations for class IV medical devices. Legislation and regulations need to be amended.

- Flanders is missing out on opportunities due to negative EU policy on genetically modified organisms.

- Ethical barriers on genetic profiling.

- Biotechnology developments are largely driven by small biotech companies without the necessary resources or long-term prospects. It is difficult for biotech companies to secure a short-term financial return.

- Importance of vision and coherent policy on training to retain a strong position in the life sciences.

- In Belgium, 25,000 people work in the pharmaceutical sector, including 7,000 innovative employees almost all of whom work for foreign companies; the food sector employs 87,000 people, 80% in SMEs. SMEs need process innovation rather than product innovation. They are looking for small value-added innovations which they can then market.

- Lack of cooperation with Flemish hospitals and knowledge institutions in clinical studies and samples.

- Many developments in this strategic cluster are taking place at scientific and technological level. It will be difficult to have products on the market by 2015.

- Importance of science and technology communication. This has repercussions in terms of recruiting students, etc.

- Bottleneck: inadequate funding for biomedical research. Sufficient investment in research infrastructure is needed in order to maintain a high competitive level.

- Healthcare applications derived from other fields have been lacking hitherto (cf. nanotechnology).

STRATEGIC CLUSTER 4

NEW MATERIALS - NANOTECHNOLOGY - MANUFACTURING INDUSTRY

A number of specific material fields, in which a considerable amount of knowledge and expertise has already been built up, will be of particular importance to Flanders in the coming years: structured nano- and micro-materials, materials for micro/nano electronics and mechanics, unique composites and materials that interact with the environment. These material-related innovations will be supplemented by a number of ancillary, but nonetheless essential, technologies. Such 'enabling' technologies include the development of specific new research and production techniques, material and product characterisation as well as the whole field of modelling, simulation and metrology.

The development of new production technologies and new materials will result in new, advanced and improved products, applications and production processes. Combining materials and material knowledge from different fields will play a crucial role in this.

In materials science, we can divide up materials based on a number of different criteria, including structural properties (nano/micro-structured, nano-mesoporous, powders, coatings, etc.), functional properties (electronic, chemical, photonic, functionally active/adaptive, etc.) and composition (metallic, physical, biological, ceramic, polymeric, etc.). Moreover, there is no absolute division between these classifications, since more and more materials have combinations of properties from different categories making them harder to catalogue. The multifunctionality of materials is and will remain very important. Indeed, the process of exchanging and combining materials and material knowledge between different fields generates many new ideas. Meanwhile, new (practical) applications for materials are being found every single day. Research into new and advanced materials is what drives innovation both in high-tech fields like ICT and micro-electronics and in more traditional sectors such as energy, building and textiles, the transport and vehicle industry and the graphics and packaging industries. Generic materials research will generate a host of new (in some cases intelligent) materials, products, research and production techniques and material treatment processes. New advanced materials with a higher knowledge content, new functions and better performance will be an ever more important factor in maintaining the competitiveness of Flemish industry.

A number of specific material-related fields have been identified and promoted as likely to be particularly important for Flanders over the coming years and in which a considerable amount of knowledge and expertise has already been built up. This strategic focusing took into account the social relevance of each of the priorities. Thus, the fields selected had to enable a relatively rapid conversion from research to practical application. Indeed, the time axis is of particular importance, and when considering which fields to set as a priority, we had to select those which (from an application point of view) we believe will be fully developed within a decade. Meanwhile, links must also be established with the existing industrial fabric and it must be ascertained whether the framework needed to realise these choices within the prescribed time limit is actually present within the Flemish business world. The priority material fields chosen in this foresight exercise are: structured nano- and micro-materials, materials for micro/nano electronics and mechanics, unique composites and materials that interact with the environment. Innovations in material technology need to be supported by various ancillary technologies, namely characterisation techniques, the development of new production technologies and the design and implementation of modelling and simulation systems. Indeed, characterisation, design and simulation are vital for a better understanding of material phenomena, for improved material analysis and reliability and for expanding virtual material design and virtual production. Integrating material technology at nano, molecular and macro level will also spur on the development of new concepts and production techniques.

Structured micro- and nanomaterials

Increased knowledge and experience with materials at nanoscale level will make it possible to create materials and systems at micro and macro level with predefined structures, properties and behaviour, in particular:

- Micro- and nano-structured materials (= non-homogeneous materials in which a particular structure at micro/nanoscale is adapted or applied);
- Nano-mesoporous materials;
- Nanopowders (e.g. for coatings) with various compositions: oxides, ceramic, metallic, semi-conductive, etc.

Materials for nanoelectronics, micro-optics, photonics, micro-mechanics, etc.

Like materials technology, electronics offers a platform for a host of developments and uses in a wide range of sectors and applications. For example, in electronics, the optical and mechanical properties of materials and products are increasingly being exploited, in addition to the electrical properties.
The electronics sector is developing principally through nano-electronics. Radical miniaturisation enables the performance, speed and capacity of electronic components to be increased (cf. 'electronic functionality'). Attention is moving slowly but steadily towards convergence with other technologies since the enormous power of micro/nano-system technology (MST/NST) can be used as a platform for the development of other applications which, although they do not involve information processing, do fall within the broad field of electronics (e.g. sensors, (O)LEDs, silicon photonics, solar cells).

- Micro-optics (including (silicon) photonics (e.g. optic chips that use micro-electronics));
- Materials with electromechanical properties (for developing actuators and sensors).

Unique composites: biomaterials, metals, ceramic materials, polymers, etc.

Over the next few years, the following unique composites will acquire much greater importance, both in research and practical terms:

- Bio(logical) materials (= materials derived from biological sources);
- Metallic materials (metals, alloys, metal compounds (oxides, carbides, etc.));
- Ceramic materials;
- Purpose-designed polymers and fibre-reinforced polymers (composites).

Materials and material systems that interact with the environment

This heading includes the following materials and material systems:

- Controlled release materials
- Coatings:
  - Functionally active and functionally adaptive layers and coatings (e.g. intelligent coatings for (bio)medical applications)
  - Self-repairing interfaces/coatings
- Nanoscale chemical or physical material systems that have a chemical or physical function or react specifically to certain chemical or physical stimuli.
- Labs-on-a-chip (= convergence between electronics and a variety of other technologies with biomedical applications): a lab-on-a-chip is actually a type of a microchip (and thus actually a material system). These microchips interact with the environment by means of a microfluid system and readout method (usually optic). Most labs-on-a-chip are made of glass or plastic, but they can also contain other materials.
- Biosensors: a biosensor is a material system usually made up of different materials (biological layer, anchoring layer, sensing layer, electronic layer).

Enabling technologies

The term 'enabling technologies' covers a wide array of technologies that play a vital supporting role in developments in other fields. They include the development of specific new research and production techniques, characterisation of materials and products, along with the whole field of modelling, simulation and metrology. The supply and marketing of enabling tools as products in their own right is a high-tech and specific market niche and a major economic activity.

Some research and application fields make little or no use of these technologies. Establishing a close relationship between these supporting technologies and the technologies they support is, however, crucial for creating added value. Besides developing these tools and making them available, there is still a long way ahead in terms of getting companies to adopt and apply them.

Combinatorial research techniques and high-throughput screening methods are a potential source of new and innovative research and production techniques. They can be a major spur to innovation insofar as they speed up the research and development process considerably by enabling parallel experimentation combined with automation and miniaturisation, thereby opening up research fields which were untapped by traditional research methods on time and cost grounds.

Material characterisation is vital in view of altering material properties and assigning additional functions to materials. It requires the development and application of advanced and complex characterisation methods and measurement standards (cf. advanced characterisation).

Modelling and simulation techniques can be used to enhance a wide variety of products and to perfect (production) processes. The virtual approach speeds up the design process drastically whilst slashing design costs. Meanwhile, the need for the quality of modelling to keep pace with these technological innovations generates new modelling approaches. In this context, we are seeing an increasingly clear trend towards multidisciplinary M&S, multi-attribute M&S, multi-scale models and integration, multi-objective optimisation and stochastic design.

It should be noted that these enabling technologies are not only important for product and process innovation but also for research itself. Indeed, characterisation, modelling and simulation are factors that can accelerate research, as physical prototypes do not need to be built for all material or system variants.

Focal points

Within this strategic cluster, the following focal points for technology and innovation in Flanders were identified, in addition to the priorities:

- Application fields and social relevance
  When determining application fields for materials innovations, synergies must be found with the existing industrial fabric wherever possible. Industrial applications for advanced materials are possible in the chemical and pharmaceutical sector, the food and textile sectors, the building sector, the graphics industry, the packaging industry, the metal sector, the energy sector, the mechanical products industry and the vehicle industry. However, social issues and problems relating to the ageing population, globalisation and the rise of the knowledge economy are also important driving forces and create a support base for materials research and development. Consequently, innovative solutions are required that will help to address research challenges in major social areas such as healthcare, communication, transport and logistics, energy and the environment.

- Human capital aspect
  Flanders currently has plenty of know-how and expertise in the field of materials science and technology. Ensuring that this remains so in the future is critical. A key task therefore is to provide appropriate training programmes and initiatives. Meanwhile, the number of scientists with technical and scientific training graduating from Flemish universities is in decline. In particular, there is a growing shortage of well trained materials experts. It is imperative that this trend be reversed. Initiatives to tackle the problem could include establishing clearer profiles and career options for materials scientists and materials engineers and including materials science more explicitly in the relevant curricula (engineering, chemistry, physics, biosciences, etc.) as a core application field for these disciplines.

- Importance of multifunctionality and cross-fertilisation between disciplines
  In general, it is possible to identify important links and overlaps between the different clusters and the materials fields. These interrelationships can generate useful cross-fertilisation. In the medium term, the convergence of knowledge and skills from different disciplines could result in application-driven

scientific and technological synergies. By adopting a multidisciplinary approach incorporating theoretical and experimental methods, a host of new developments and applications may be realised. The importance of this cannot be underestimated. For example, nanomaterial developments for medical and life science applications constitute a kind of enabling technology, a platform on which applications from strategic cluster 3 ("Healthcare - Food - Prevention and Treatment") can propagate or develop.

- Research input/output
  We need to avoid complacency when it comes to the relationship between research input (resources) and research output. We score highly on materials knowledge and research, but the question is whether the available resources are being used optimally and whether it would be possible to further optimise output with existing resources by means of greater coordination, more complementarity and clear agreements between research groups. Optimisation can be achieved by seeking out complementarity, stepping up cooperation and avoiding the duplication and overlapping of research lines.

- Cooperation between business and knowledge institutions
  Research cooperation between the business world in general and research centres could be improved. Much more could be achieved through more efficient collaborative ties between knowledge centres and companies. This is possibly more of a problem for SMEs than for large companies, who are indeed beating a path to the door of knowledge institutions. A lot depends on the specialisation of individual research centres. Whereas some team up mainly with Belgian companies, others work mostly with companies from abroad. Thanks to the technology advice centres, SMEs too can allocate specific research assignments to knowledge centres. These centres do bring together a relatively large group of SMEs who together develop research project proposals that can be submitted to a knowledge centre. Alongside this, great efforts are required to boost the absorption capacity within business and industry and to foster the mobility of researchers between industry and knowledge institutions.

- Innovation paradox
  The innovation paradox is an unmistakable factor in this discussion. We have a lot of very valuable knowledge in a large number of fields. However, when it comes to translating and converting this knowledge into economic capital by developing business activities, Flanders and its research

community could be doing much better. Although we are at the top in numerous technological fields, we often lack the capacity to convert this knowledge and innovation into value-adding economic activities. A major challenge is therefore to develop activities and services that make us better at marketing and capitalising on our technological knowledge. We need to identify the root causes of this shortcoming and work out how we can remedy it. A number of ancillary services can be grouped together under the heading 'support for generating added-value creation', including market research, market analysis, etc. These will examine where technological developments may lead from a market perspective, how markets are likely to evolve, how big they will be, and so on. Based on this information, we can then decide where our knowledge and technology can have the biggest contribution. The ultimate aim of these activities is to actively support development in areas that will actually lead to marketable, value-added products. Support for generating added-value creation is particularly important for SMEs.

In addition to this, the capacity of some industries or companies to assimilate existing and new technological developments is often too limited. In many cases they do not need to develop new generic technologies, they could make substantial progress simply by incorporating more of the existing technological knowledge into their activities. Many of these players are SMEs, who in general remain very conservative when it comes to using existing understanding, knowledge and techniques. This clearly is an illustration of the existence of the innovation paradox in Flanders.

- Open borders (international focus)
  Flanders should not be viewed as an independent entity where the entire research and innovation chain must be present and operating in order to keep business afloat. We must take into account the international context; after all, companies will take inspiration wherever they can find it, whether in Flanders or elsewhere. Naturally it is often more profitable and efficient to have a knowledge centre close at hand. However, not all research fields require the entire value chain to be present in Flanders. What we should be working towards, therefore, is global rather than local optimisation. Open innovation works in both directions and knowledge institutions need to offer valuable insights to companies both at home and abroad. Consequently, it is important that Flemish knowledge institutions excel internationally as well as in Flanders.

- Chemical industry
  The term 'molecular materials' can be applied to an enormous number of materials, since many properties are built into the molecular bricks out of which these materials are made. Chemistry has a key role to play throughout the material creation process. When producing a material, the chemistry of the material has to be very tightly monitored and controlled. Knowledge of chemistry is therefore vital, as it is in the design of new materials. Moreover, Flanders' chemical sector is at present, economically speaking, a very important and very large value-adding industry.
  This said, it faces, however, a major challenge, one that should arguably be considered a top priority: the rising costs and limited global supplies of fossil fuels will force the sector to switch from fossil fuels (oil, coal, etc.) to alternative raw materials, such as biomass.

STRATEGIC CLUSTER 5

ICT FOR SOCIO-ECONOMIC INNOVATION

The development of advanced networks where users are connected in all places and at all times ('Always connected', 'Multi-access') is central to innovating our socio-economic fabric. Vital, in this respect, is the continued technological development of broadband, mobile and wireless applications. One frequently cited aspect is the need for universally available ICT facilities and applications ('ambient intelligence') that are both context-aware (cf. information service that considers user context) and user-friendly. Improved security (cf. privacy/security) of these information services is also high on the agenda.

The convergence of technologies and multidisciplinary fields (cf. Bio-Nano-Cogno-Info integration) and the development of new applications as a result of this convergence constitute a major challenge. Sweeping computerisation and a focus on innovation in socio-economic sectors (cf. e-health, e-society) are important for the further development of our knowledge society. Government can play an important role here.

The development of new ICT services depends heavily on a number of critical success factors. In this respect, the Flemish government can create the right environment or context to enable an array of innovative ICT services to be developed and exported.

Advanced networks: Broadband/Mobile/Wireless ('Always connected', 'Multi-access')

The information society is heavily dependent on its infrastructure, where innovation is connected with the ability to use and combine information from internal and external sources. Advanced networks are therefore indispensable for our modern knowledge economy. With the internet becoming a pervasive presence, society is evolving into an intelligent environment in which consumers can use a huge variety of information, wirelessly anytime ('Always connected') and anywhere ('Multi-access'). Further development towards greater bandwidth, mobile and wireless applications is considered a priority.

BROADBAND

Broadband is a rapid data transmission channel operating at a speed of several megabits per second. It can work in various ways (fibreglass, cable, telephone line, wireless, even via the electricity network) and therefore offers the potential to develop new high-quality services in the field of data distribution, video/internet telephony (Voice over Internet Protocol, VoIP), webcams and streaming video.

MOBILE AND WIRELESS APPLICATIONS

Wireless and mobile services will soon be the rule rather than the exception, enabling people to access the internet, their e-mail and personal data anywhere, anytime. This development is based on technologies such as Bluetooth (wireless communication between devices up to 10 metres apart), WiFi (for wireless Local Area Networks of up to several hundred metres) and WiMax (for long distances up to several tens of kilometres), not forgetting of course GPRS and UMTS, the 'high-speed' successor to GSM for mobile phones and PDA. Companies/institutions are increasingly using wireless handheld computers to consult client data and record work carried out (entry at source).

Properties/criteria of advanced networks

USER-FRIENDLINESS AND AMBIENT INTELLIGENCE

One of the R&D priorities being promoted is making ICT services less complicated and more user-friendly (by introducing general standards, for instance), in particular those that significantly enhance consumer convenience. Incorporating some degree of intelligence (embedded intelligence) into ICT is a key part of this.

Advanced networks must also be 'ambient intelligent', making ICT omnipresent, even in everyday objects (clothes, etc.). ICT therefore needs to be adapted to the cognitive style of the user, so that the ICT service and user can interact in as relaxed and natural way as possible (e.g. in natural speech). Bringing about this technological revolution requires in-depth knowledge of how people interact with computers (developments in the field of cognitive sciences will be important here). Therefore, IT training will need to pay due attention to the interaction/interface between user and ICT service.

CONTEXT AWARENESS

Context awareness is a property of IT devices used in various day-to-day situations which allows them to take into account various user characteristics and preferences.

Common examples of context are the location and movement of the user.

An example of a context-aware application in the tourism sector is where the information that appears on the user's device (e.g. a PDA) is personalised and takes into account his or her preferences (if the user indicates a 'cultural' preference, the device might show the location of the nearest museum, for example).

A simple example of a business application might be a telephone that switches automatically to silent mode when its user is engaged in an important activity such as a meeting: the application then compares the electronic diary data with the status of the mobile phone.

SECURITY/PRIVACY

A lot of work is needed to solve the security problems associated with intelligent networks in order to guarantee privacy, protect data and avoid computer viruses, spam and the like. This development will be a critical success factor for a number of areas in particular, including wireless communication, autonomous sensor networks and medical applications. Moreover, with the arrival of the pervasive internet the problem of security will become increasingly acute.

Converging technologies and application development

The process of increased cooperation - or even assimilation - between a large number of disciplines is seen as very important and offers a wealth of opportunities. This process is known as technology convergence. Nanotechnology, information technology, biotechnology and the cognitive sciences are moving closer together (Nano-Info-Bio-Cogno integration). This convergence of highly specialised science offers huge growth potential as well as opportunities to develop new applications.

E-applications: e-health and e-society

ICT is permeating the social and economic fabric of our society to an ever larger extent.
In recent years, attention has increasingly turned to various kinds of e-applications such as e-work, e-media, e-transport, e-health and e-society. E-health and e-society are considered as priorities.

E-health refers to the integration of ICT into healthcare to enhance the quality of service, make working practices more cost-efficient and optimise time management for healthcare professionals, with a view ultimately to better healthcare provision.
E-health applications have been gaining ground in recent years.

E-society refers to the creation of so-called 'communities' (e.g. web-based learning communities, web-based classifieds such as Craigslist). The exponential increase in internet users and the emergence of social software models have spurred on the social development of the internet. The Flemish government could usefully examine how it can support these new kinds of communities with a view to strengthening the social fabric.

The Flemish government can play an important role in promoting such e-applications (by means of innovative contracting, the provision of testing grounds, etc.).

Focal points

The development of new ICT services and applications is heavily dependent on a number of transversal critical success factors. In this respect, the Flemish government can create the right environment or context to enable an array of innovative ICT services to be developed and exported. These factors are outlined below.

- Living action lab for test users
  The industry is only too aware that the driving forces behind the development of new ICT products and services are not technological developments but the needs and demands of users. It is users who determine today's market and who decide whether technologies are user-friendly enough to make them successful. To understand the needs and demands of users, living action labs can be created where a technology is tried out by test users who then give their feedback. This allows companies to fine-tune and market their applications.

- The Flemish government as first customer
  By being the first customer for new applications, the government can play a key role in launching new ICT products. This support does not need to be financial: the government could allow a company to use a hospital or social assistance centre as living action labs for a newly developed e-health application (similar options exist for e-learning in schools, e-security, etc.). The application can thus acquire the references it needs to gain further access to the market.

- Balanced support for the whole innovation chain
  The government could facilitate the development of innovative applications by providing more balanced support for the whole innovation chain, from the long-term basic research where ideas are generated right through to the testing stage. Care must be taken not to focus exclusively on one aspect of the innovation chain.

- Cooperation between companies in an open research and innovation model
  One of the key factors for developing successful applications is that companies work together in an open (research) model (cf. Scandinavian countries). An open model will find more acceptance among companies if the government provides common platforms and resources (see also 'government as first customer').

- Informing SMEs about financing sources
  The active involvement of SMEs is vital given the key role they play in fostering innovation. It is therefore important that SMEs are informed about best practices and market entries and that appropriate financing sources (e.g. the government) are identified.

- Encouraging creativity
  It is important to encourage creative ('crazy') ideas among young people as these can lead to ICT service concepts with a significant market impact.

STRATEGIC CLUSTER 6

ENERGY AND ENVIRONMENT FOR SERVICES AND MANUFACTURING INDUSTRY

Energy and environmental technology play an important role in the development of innovative energy generation and use, as well as of sustainable production processes and products for services and manufacturing industry. These technologies are not only important within Europe but represent a prominent and rapidly growing global market with major export opportunities. Energy and environmental technology can also help to address big socio-economic challenges such as global climate change, the exhaustion of fossil fuel sources, environmental sustainability, as well as competitiveness and economic growth. The technologies identified as priorities for Flanders are mainly geared towards more efficient use of energy in industry and buildings. Innovation in energy generation (cf. solar energy, biomass, efficient use of fossil fuels, nuclear energy and fuel cells) should be a focal point here. Another key factor are 'smart grids', where energy is generated and distributed locally in an integrated and efficient way. Environmentally friendly production processes (cf. 'closed loop'), industrial and agricultural biotechnology and water, air and soil remediation are also likely to contribute to the sustainability of production processes and products.

Efficient use of energy in Industry and Buildings

Efficient use of energy is an important strategy for safeguarding (future) energy supply, economic growth and environmental protection. Energy efficiency can be achieved in both industry and buildings.

EFFICIENT USE OF ENERGY IN INDUSTRY

Efficient use of energy can be realised in a wide range of energy-intensive industrial branches, including chemicals, aluminium, steel, pulp and paper, cement, glass and ceramics, food and textiles. Possibilities for technological innovation include combined heat and power generation (known as 'cogeneration') and new electrotechnologies (cf. steel production using microwaves).

EFFICIENT USE OF ENERGY IN BUILDINGS

The most important R&D requirements when it comes to efficient use of energy in buildings can be grouped into three categories:

[1] The building shell (advanced insulation techniques, window technology such as thermal insulation and built-in solar cells, recycled building materials, etc.).

[2] Equipment and appliances (performance improvements by means of more efficient heat pumps, new cooling techniques, magnetic and thermo-electric technologies, energy-efficient lighting, innovative decentralised energy systems such as micro-cogeneration, etc.).

[3] Hardware and software development for intelligent systems/smart buildings (see also 'smart grids').

Integrated concepts such as the 'passive house' could become the building norm of the future and open up new prospects for more future-oriented, energy-efficient design and construction. By combining a well thought-out, compact, sun-facing design with excellent insulation and effective draft-proofing, a passive house allows almost no heat to escape. This is a unique opportunity for the construction industry to make a mark with new design and building techniques, innovative, intelligent and highly energy-efficient products for integrated insulation systems, ventilation systems, glazing, frames, windows, doors, compact heating systems and so on. These investments in comfort, efficiency and building quality could give the construction sector a shot in the arm, create added value, improve its competitive position and generate sustainable employment gains.

Smart grids

Continuity of power supply cannot be guaranteed at a time when all links in the generation-grid-user chain are evolving rapidly. Black-outs can cause major upheaval and disruption to economic processes. Smart grids are therefore a prerequisite for ensuring a high degree of penetration of distributed power generation. One might talk of a 'power web', by analogy with the world wide web: whereas the latter involves data flows, the 'power web' needs to allow energy to flow in different directions and must therefore be efficiently connected (importance of power electronics). This requires the development of hardware, e.g. for operating and measurement purposes, and also of highly reliable software for controlling the system and its components.

Energy generation

SOLAR ENERGY

Solar energy is a renewable energy source that could eventually supply a substantial part of our energy (see also 'efficient use of energy in industry/buildings'). The sector is growing very rapidly and has great economic potential, mainly due to national market stimulation programmes in the EU and Japan. Research, both technological and fundamental, is considered necessary.

BIOMASS

Biomaterials and bio-waste are used to produce solid, liquid and gaseous fuels that can be used in the transport sector, for power generation and heating applications. Although many biomass technologies are highly advanced, there is still room for more efficiency and improved cost-efficiency (cf. various biomass conversion technologies such as fermentation to bio-ethanol, anaerobic digestion, etc.). Biomass could be an economically attractive alternative for the agricultural industry.

EFFICIENT USE OF FOSSIL FUELS

Most energy today is generated from fossil fuels (coal, oil, gas). Fossil fuels can be used (sometimes combined with biofuels) for various technologies that generate electricity, heat or a combination of the two. Fossil fuels are also used as raw materials in a large number of industrial sectors (cf. plastics). A key challenge is to find better ways of using these fuels whilst minimising their environmental impact. We can expect to see developments in the fields of efficiency improvement and cleaner new technologies.

NUCLEAR ENERGY

Nuclear energy is an important long-term solution for the problems of CO_2, fossil fuel dependency and energy supply. Technological developments in nuclear energy are taking place in various areas, such as safety at nuclear power stations and R&D linked to the storage/removal/recycling of radioactive material. Efforts are also focusing on developing more compact and efficient types of power stations.

FUEL CELLS: FOCUSING ON FUEL CELL DEVELOPMENT WITHIN KNOWLEDGE INSTITUTIONS

Innovative fuel cell technology could replace existing technologies (e.g. lithium-ion batteries) in a multitude of applications (portable appliances such as mobile phones and laptops, cars, decentralised energy systems such as fuel cells for micro-cogeneration, etc.) and could be important for decentralised energy generation (cf. solar energy, wind energy, mini- and micro-cogeneration using sterling engines). Flemish knowledge institutions must make the development of fuel cells a constant focus of attention.

Sustainability of production processes and products

ENVIRONMENTALLY FRIENDLY PRODUCTION PROCESSES ('CLOSED LOOP')

Production processes and equipment will undergo drastic changes in future under the pressure of increased cost-efficiency and as environmental consciousness (cf. 'closed loop') and the needs of users increase. These factors will need to be taken into account at every level and stage of the production process.

A number of key elements will enable the development of a new production environment:

- Better understanding of the interactions between materials and processes
- Improved process knowledge based on mathematics, physics and chemistry
- Development and application of high-performance production information systems and new programming platforms.

Most environmentally friendly production processes can be created within individual production and consumption sectors such as pulp/paper, plastic, iron/steel, construction, chemicals and textiles.

INDUSTRIAL BIOTECHNOLOGY

Industrial (white) biotechnology promises to yield greater efficiency and a more sustainable production process (less waste, less energy consumption and the use of biomass as a renewable raw material) than traditional chemistry and can be used in various sectors: pharmaceuticals (cf. red biotechnology), chemicals (cf. with industrial-scale biotechnology to produce biodegradable chemicals using living cells and their enzymes), food production (cf. beer, cheese, wine, etc. using micro-organisms) and so on.
The use of genetically modified organisms in production processes offers especially great potential.

AGRICULTURAL BIOTECHNOLOGY

In the agricultural and food sector, increased knowledge of genetics and molecular biology is expected to result in more and more genetic interventions on crops, micro-organisms and animals. This will make it possible to create crops that are more in line with the needs of consumers and industry. Priorities here are: more efficient use of agricultural land, improved quality, enhanced resistance (making it possible to cut pesticide use) and improved yields. Another key factor is the need to raise awareness among the public, who are currently very wary about these developments.

WATER, AIR AND SOIL DECONTAMINATION

A well-functioning economy takes a toll in the form of water, air and soil pollution (e.g. heavy metals in soil and water, particulate matter and ozone in the air).
Consequently, there is a strong demand for decontamination technology, both at home and abroad.
In this priority field, the biggest need is for further technological improvements, with companies taking the real initiative.

PRECONDITIONS

FOR INCREASING FLANDERS' INNOVATIVE STRENGTH

Across all the strategic clusters, the experts also identified and highlighted a number of focal points, not necessarily relating to a particular field. These more contextual preconditions and critical innovation factors could potentially have a major impact on Flanders' innovative strength. The following preconditions were highlighted:

1) Availability of risk and venture capital
2) Connection to international networks/partners with a view to effective market operation
3) Labour market flexibility
4) Labour costs of researchers
5) Fiscal incentives - taxation
6) Public procurement: capitalising on the role of the government - as a purchaser of products/services - in enhancing the effective diffusion of innovation/growth of innovative enterprises
7) Long-term vision (continuity) on research funding
8) Availability of human capital in science/technology fields
9) Development of new learning methods/curricula enabling faster/more targeted knowledge acquisition within secondary and higher education and adult education (life long learning).
10) Science and technology communication targeting users/consumers
11) Presence of R&D settings geared towards experience (cf. ‘living action lab’ concept enabling rapid/effective knowledge acquisition geared towards commercial exploitation)
12) Transfer/feedback of technological innovation to SMEs (for practical application)
13) Flexible approach to dual use (i.e. civil and military applications)
14) Stable, non-restrictive legislation and regulatory process
15) Less bureaucracy

A questionnaire was then filled in (by 85 respondents across the six strategic clusters) regarding these preconditions. It asked:

1) how important they were for increasing Flanders' innovative strength (on a five-point scale ranging from moderately important to important to essential);
2) what was Flanders' current position with respect to each condition (on a five-point scale ranging from insufficiently to averagely to highly competitive).

The outcome of the survey was unambiguous (see Table 2): all of the preconditions could be considered as 'important', 'very important' or 'essential' for Flanders' innovative strength. Moreover, Flanders' current position with respect to the different preconditions was perceived as 'insufficiently' to 'averagely' competitive. In this way, the experts identified a set of preconditions which were then systematically classified based on the questionnaire. Naturally, these preconditions can be further refined based on quantitative economic analyses to gain a more detailed insight into possible policy implications and resulting policy suggestions. However, this was not one of the aims of the present study.

Table 2: Questionnaire on the preconditions for Flanders' innovative strength: overview of results

Preconditions	Importance for increasing Flanders' innovative strength	Flanders' current position
Availability of risk capital	Essential (5)	Insufficiently to averagely competitive (2)
Connection to international networks/partners for effective market operation	Essential (5)	Averagely competitive (3)
Labour market flexibility	Very important (4)	Insufficiently to averagely competitive (2)
Labour costs of researchers	Very important (4)	Insufficiently to averagely competitive (2)
Fiscal incentives - Taxation	Very important (4)	Insufficiently to averagely competitive (2)
Public procurement	Very important (4)	Insufficiently to averagely competitive (2)
Long-term vision on research funding	Essential (5)	Insufficiently to averagely competitive (2)
Availability of human capital in science/technology fields	Essential (5)	Averagely competitive (3)
Development of new learning methods/curricula	Very important (4)	Averagely competitive (3)
Science and technology communication targeting users/consumers	Very important (4)	Averagely competitive (3)
Presence of R&D settings geared towards experience	Very important (4)	Averagely competitive (3)
Transfer/feedback of technological innovation to SMEs	Very important (4)	Insufficiently to averagely competitive (2)
Flexible approach to dual use	Important (3)	Averagely competitive (3)
Stable, non-restrictive legislation and regulations	Essential (5)	Insufficiently to averagely competitive (2)
Less bureaucracy	Very important (4)	Insufficiently to averagely competitive (2)

(The score 1-5 given in brackets indicates a) how important most experts consider the condition to be for increasing Flanders' innovative strength and b) the strength of Flanders' current position with respect to the condition: the higher the score, the more important the condition/more competitive the current position.)

PART 2
CONCLUSIONS AND RECOMMENDATIONS

Expert-approved prioritisation of technology and innovation in Flanders

1. The Council fully endorses the prioritisation of the 30 technical and economic developments and 15 critical innovation factors defined by the expert panels within the six strategic clusters.

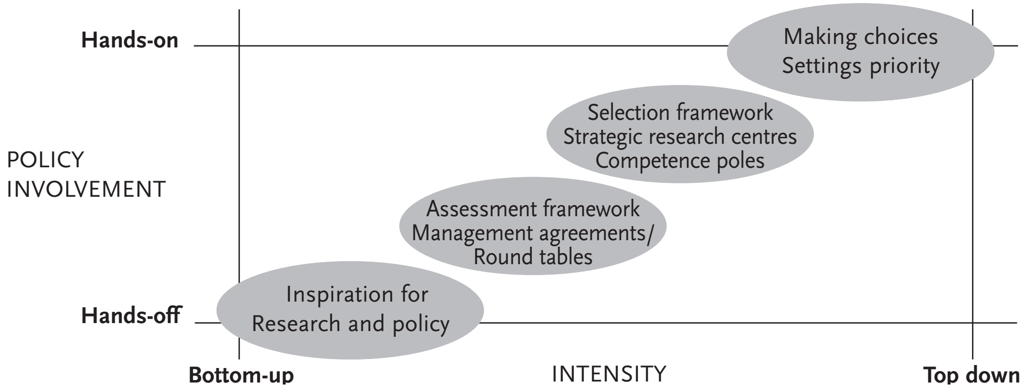
2. The prioritisation is the result of an interactive and iterative process involving 130 technical and economic experts from industry and knowledge institutions divided into six panels, one for each Strategic Cluster. Working on the basis of an international trend analysis, the expert panels started with around 160 technical and economic developments, from which they selected 30 priorities for Flanders based on a strength/weakness analysis.

3. To increase Flanders' innovative strength, the Council stresses the need to pay simultaneous and coordinated attention to both priorities (trends) and critical innovation factors (preconditions). It emphasises the major responsibility of both the government and social partners in this respect.

Valorisation of the prioritisation by government, industry and knowledge institutions

4. The Council considers this prioritisation of technology and innovation to be a reference framework for all stakeholders in Flanders: the government, industry and knowledge institutions. Valorisation of the reference framework operates in two dimensions: intensity, ranging from active influence to guidance, and policy involvement, ranging from hands-off to hands-on (see Figure 1).

Figure 1: Valorisation of the reference framework



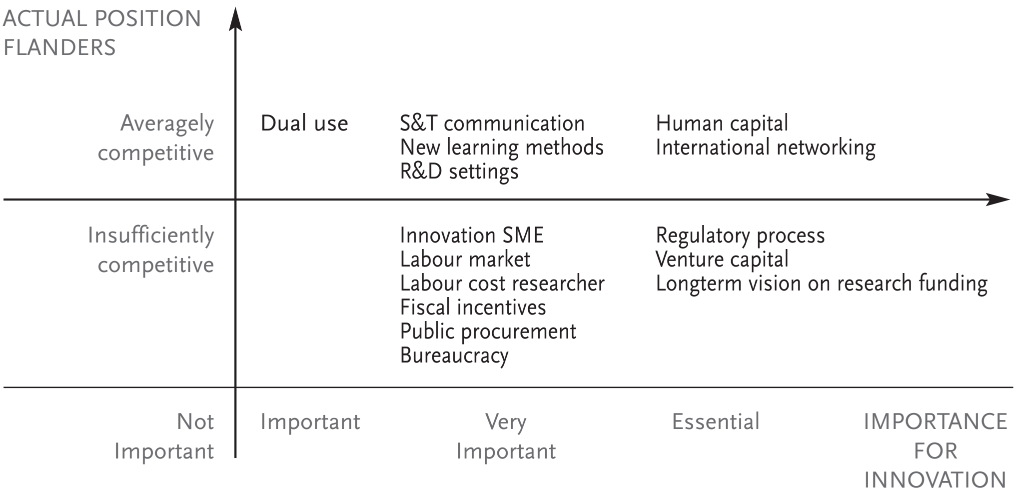
Government

5. The Council proposes to use this reference framework initially as an assessment framework for existing instruments and initiatives. In recent years the Flemish government has already created a whole array of instruments covering the entire innovation chain, for which the reference framework may provide useful information:

- New applications within the policy framework for strategic research centres (SRCs) and competence poles could be assessed against this reference framework.
- The reference framework could be used when drawing up management agreements/ convenants for new and existing SRCs and competence poles. In fact, the existing SRCs VITO, IMEC, VIB and IBBT, and the competence poles VIL, Flanders Food, FLAMAC, FMTC, MIP and Flanders Drive, have a clear link with the six strategic clusters.
- The expert-approved prioritisation may also be a vehicle for further implementing the Round Table concept within a strategic cluster. It will be an innovative and pioneering stimulus with added value for innovation policy in Flanders.
- The reference framework could also serve as a guide for the Flemish Innovation Policy Plan, which aims to integrate innovation-related activities into all policy areas handled by the Flemish government, such as environment, healthcare, logistics and transport. In this connection, the VRWB refers to its 100th recommendation on the Flemish Innovation Policy Plan of 30 March 2006.

6. In the Council's view, the government also has an important role to play as a catalyst in increasing Flanders' innovative strength. It dealt with this question extensively in its April 2004 memorandum. During the prioritisation process, the six expert panels identified the following 15 preconditions for increasing Flanders' innovative strength, known as structural innovation. Figure 2 illustrates the importance for innovation and Flanders' current position with respect to these 15 preconditions.

Figure 2: The importance for innovation and Flanders' current position with respect to the 15 preconditions, as perceived by the six expert panels.



Industry

7. This expert-approved prioritisation will also be submitted to the sector federations for further implementation within their respective sectors, in line with the defined priorities. This will broaden the support base still further.

Knowledge institutions

8. This expert-approved prioritisation will also inspire research and development at research institutions and associations.

Importance of this foresight study for innovation-related activities in Flanders

9. A knowledge-intensive society cannot operate without regular, well-founded discussions on the developments taking place in technical and economic fields. Flanders is no exception, and requires such discussion exercises at macro-level. A more systematic approach to foresight studies will create a framework for Flemish policymakers that is capable of supporting and justifying strategic policy choices on technology and innovation issues. The foresight study is a lively, dynamic process with a broad support base that dovetails nicely with European initiatives.

10. With this study, the VRWB has succeeded in getting all of the stakeholders significantly involved in innovation-related activities, and therefore in the future of Flanders. Expert panels comprising a large number of highly competent and committed experts from industry and knowledge institutions have worked together to develop a vision for the future and in so doing have reached a consensus. These experts have high hopes for the future and are willing to continue to work together on innovation-related activities in Flanders.

Danielle Raspoet
Secretary
Flemish Science Policy Council

Karel Vinck
President
Flemish Science Policy Council

ANNEXES

Foresight Steering Committee (from 1-1-2005 till 31-12-2006)

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Martin De Prycker, CEO, Barco
Steven De Waele, Science and Innovation Adviser to Flemish Vice-Minister President Fientje Moerman (replacing Danielle Raspoet from 1 April 2006)
Julien De Wilde, former CEO, Bekaert
Elisabeth Monard, Secretary-General, Research Foundation - Flanders (VRWB Secretary until 31 October 2005)
Prof. Leo Sleuwaegen, Dept. Applied Economics, K.U.Leuven
Jean Vandemoortele, President of the Group Executive Committee, Vandemoortele
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Marc Van Sande, Executive Vice-President, Umicore
Philippe Vlerick, CEO, BIC-Carpets

VRWB:
Danielle Raspoet, Secretary (from 1 April 2006)
Elke Smits, Project coordinator, Senior researcher

Expert Panel for Strategic Cluster 1
'Transport - Logistics - Services - Supply Chain Management'

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Prof. Luc Chalmet, Dept. Management Information Systems, University of Antwerp
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André De Vleeschouwer, Programme Manager, IBBT
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Prof. Marc Lambrecht, Faculty of Economics and Applied Economics, K.U.Leuven
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Jozef Maes, Senior Vice-President Marketing & Sales, Asco Industries
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Luc Meert, Cross Entity Healthcare, Siemens Medical
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Prof. Stefaan Peeters, Dept. Physics, University of Antwerp
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Filip Schutyser, CEO, Medicim
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'New Materials - Nanotechnology -Manufacturing Industry'

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'ICT for Socio-economic Innovation'

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'Energy and Environment for Services and Manufacturing Industry'

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With the scientific support of:
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LIST OF ABBREVIATIONS

DNA	Deoxyribonucleic Acid
EU	European Union
FLAMAC	Flanders Materials Centre
FMTC	Flanders' Mechatronics Technology Centre
FWO	Research Foundation - Flanders
IBBT	Interdisciplinary Institute for BroadBand Technology
ICT	Information and Communication Technology
IMEC	Interuniversity Microelectronics Centre
IT	Information Technology
(O)LED	(Organic) Light Emitting Diode
M&S	Modelling and Simulation
MIP	Environmental and Energy Technology Innovation Platform
R&D	Research and Development
RNA	Ribonucleic Acid
SME	Small and Medium Enterprises
SRC	Strategic Research Centre
VIB	Flanders Institute for Biotechnology
VIL	Flanders Institute for Logistics
VITO	Flemish Institute for Technological Research
VRWB	Flemish Science Policy Council

LIST OF TABLES AND FIGURES

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Publication of the Flemish Science Policy Council (VRWB), June 2007

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Previous publications (only available in Dutch):

Studiereeks 1: *"Het ontwikkelen van een deflator voor O&O-uitgaven"*
Studiereeks 2: *"Wetenschappelijk Onderzoek: Tussen sturen en stuwen. Acta van het colloquium"*
Studiereeks 3: *"O&O-bestedingen van de Vlaamse Universiteiten"*
Studiereeks 4: *"Wetenschappelijk onderzoek en de genderproblematiek"*
Studiereeks 5: *"Biotechnologische uitvindingen, octrooien en informed consent"*
Studiereeks 6: *"Perspectieven uitgestroomde wetenschappers op de arbeidsmarkt"*
Studiereeks 7: *"De doctoraatsopleidingen aan de Vlaamse Universiteiten"*
Studiereeks 8: *"Het 'grote' begrotingsadvies. Wetenschaps- en technologisch innovatiebeleid 2002"*
Studiereeks 9: *"Wetenschappers: luxe of noodzaak?"*
Studiereeks 10: *"Samenwerking tussen kennisinstellingen en bedrijven inzake onderzoek(sresultaten): intellectuele eigendomsrechten, conflicten en interfaces"*
Studiereeks 11: *"De chemische industrie in Vlaanderen"*
Studiereeks 12: *"De voedingsindustrie in Vlaanderen"*
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