



# Annual Review 2000

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TNO is a leading independent contract research company where nearly 5,200 professionals pool their expertise and research to make a substantial contribution to the competitiveness of businesses and organisations, to the economy and to the quality of society as a whole.

Through its versatility and capacity to integrate this knowledge and expertise, TNO occupies a unique position as a link within the innovation chain – between fundamental research as a source of knowledge and practical application for the use of knowledge.

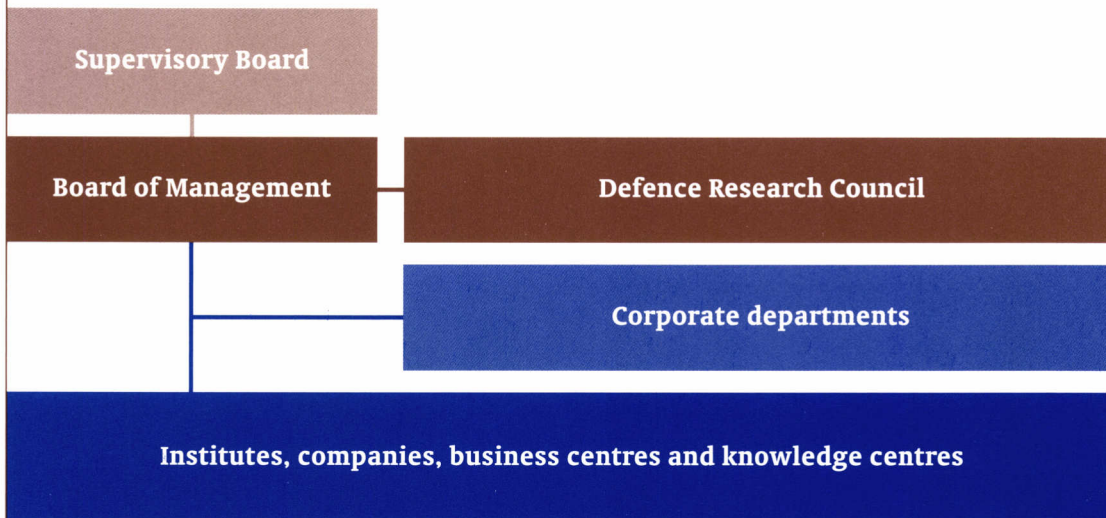
TNO's commitment to facilitating the interests of a broad range of businesses as well as organisations and governments is underlined by a strong focus on quality, creativity, accessibility and entrepreneurship.

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TNO Annual Review 2000 is an abridged version of the Dutch 'TNO Jaarverslag 2000'.  
In matters of interpretation the Dutch text will prevail.

## Organisation structure



# Key figures

in millions of euros (unless otherwise stated)

	2000	1999	1998
Government funding turnover	154.2	144.5	144.4
Market turnover TNO	295.1	279.6	242.4
Turnover TNO	449.3	424.1	386.8
Turnover group companies	36.2	21.1	19.0
Consolidated market turnover	325.3	295.9	259.1
Consolidated turnover	479.5	440.4	403.5
Net turnover <sup>1)</sup>	409.5	370.6	334.2
Added value <sup>2)</sup>	338.7	305.6	261.9
Result before personnel profit sharing	7.3	7.8	6.8
Personnel profit sharing	–	1.9	–
<b>Result</b>	<b>7.3</b>	<b>5.9</b>	<b>6.8</b>
Result as % of market turnover	2.3%	2.0%	2.6%
Operating result	3.1	9.1	-0.6
Operating result TNO institutes	2.0	8.4	9.3
Result TNO institutes	1.8	9.0	10.8
Number of TNO employees (effective average)	4,659	4,518	4,073
Number of employees at group companies (effective average)	338	182	140
Total number of employees (effective average)	4,997	4,700	4,213
Net turnover per employee in euros x 1,000 (effective average)	81.9	78.9	79.3
Added value per employee in euros x 1,000 (effective average)	67.8	65.0	62.2
Personnel costs per employee in euros x 1,000 (effective average)	59.6	56.2	55.1
Personnel costs	297.8	264.2	232.2
Operating capital	12.6	21.2	52.7
Equity	209.9	206.9	202.7
Cash flow	46.1	56.7	38.5
Capital expenditure	58.9	75.8	53.4
Average term (in months) for work in progress and debtors (TNO Institutes)	3.8	4.5	4.4
Current ratio	1.09	1.17	1.49
Solvency	0.54	0.57	0.57

1) – Net turnover = turnover – direct project costs

2) – Added value = turnover + other operating income – external costs

## **TNO Supervisory Board**

(composition as at 1 April 2001)

J.M. Leemhuis-Stout, M.Sc., *chairman*  
Prof. Dr M.C.E. van Dam-Mieras  
Prof. Dr P.M.E.M. van der Grinten  
Prof. Dr L. Koopmans  
Dr H.J. van der Molen  
A.H.J. Risseeuw, M.Sc.  
Dr A.W. Veenman  
J. Vrolijk, LL.M.  
H.P.C. Wellen, LL.M., *secretary*  
P.O. Box 6000  
NL - 2600 JA Delft  
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## **TNO Defence Research Council**

(composition as at 1 April 2001)

E.I.L.D.G. Margherita, M.Sc., *chairman*  
Cdr. D. van Dord, M.Sc., *vice-chairman*  
Sbn. P.M. van der Struis  
Genm. W.H. Zoomers, LL.M.  
Gen.maj. P.M.A. Vorderman  
Cdre. J.M.W. Willems, M.A.  
J. Bezemer, M.A.  
Ktz. W. Nagtegaal  
Prof. Dr E. Backer  
Prof. Dr L.F.W. de Klerk  
Prof. K.F. Wakker  
Prof. Dr R. de Wijk  
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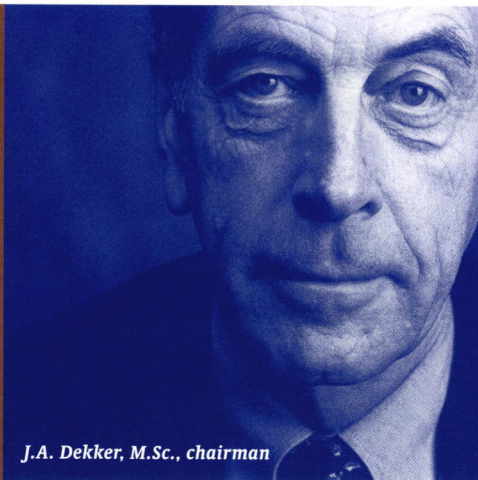
## **TNO Board of Management**

(composition as at 1 April 2001)

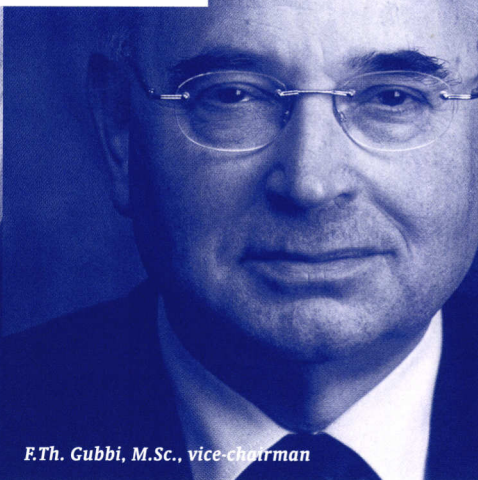
J.A. Dekker, M.Sc., *chairman*  
F.Th. Gubbi, M.Sc., *vice-chairman*  
Prof. Dr P. Folstar  
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TNO in 2000

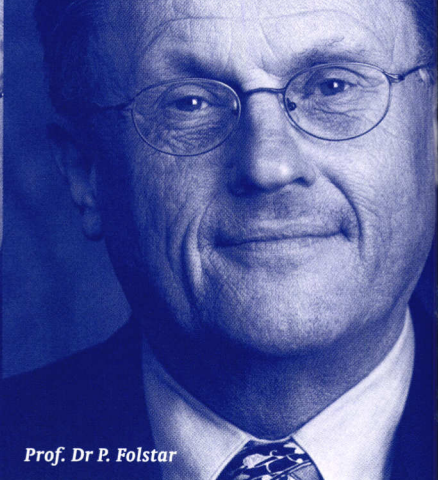
# Abridged report from the TNO Board of Management



*J.A. Dekker, M.Sc., chairman*



*F.Th. Gubbi, M.Sc., vice-chairman*



*Prof. Dr P. Folstar*

## Introduction

For TNO the year 2000 was something of a double-edged sword. Many areas saw a lot of hard work being undertaken and most objectives as set for the year 2000 in the 'Agenda for TNO', the strategy for the period 1999-2002, have been achieved. Yet in contrast to this favourable development, the result of € 7.3 million, some € 0.5 million less than that of 1999, was disappointing. A closer look at the composition reveals that the operating result underperformed, though this was partly compensated by savings and one-off revenues.

The result justifies decisions that have already been made and actions that are already underway to devote extra attention to the internal operation of the company. In addition, TNO is looking carefully at its portfolio of activities. Activities that no longer meet the demands of the market and which are no longer profitable will be quickly terminated. By contrast, there are areas of considerable quality and potential within TNO that have plenty of opportunity to grow more quickly. Society is fully entitled to expect TNO to carry out its work competently and efficiently. The ultimate purpose of the efforts and investments made by TNO is not to accumulate knowledge per se, but to utilise knowledge to undertake useful work for society and our clients, as well as to implement successful innovations. This is also expressed in TNO's mission statement. It is the extensive knowledge and experience along with the energies of colleagues and the organisation that put TNO in a position to fulfil this mission now and in the future: to contribute to the solution of social problems and to the expansion of our clients' capacity for innovation.

## Strategy

TNO lays out its plans for the future in a strategy, which is drafted every four years and presented to the Dutch Cabinet for approval. The present strategy, the 'Agenda for TNO' runs from 1999 until 2002. The end of the year 2000 falls at the halfway point of this period. Progress is measured annually by analysing TNO's core areas and corporate actions.

The analysis for 1999 showed that the great majority of the strategic objectives for that year had been achieved. In 2000, too, the great majority of TNO's strategic resolutions remained well on course. The detailed report of the year 2000 is due to appear in May 2001. Meanwhile preparations are under way for the formulation of a new strategy that must be ready by the start of 2002.

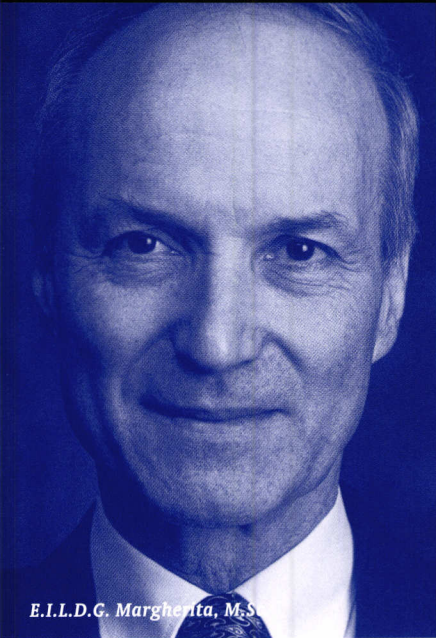
## Finances

The result fell € 0.5 million short of expectations, with the operational result of most institutes performing well below expectations. Some institutes even booked a negative result, though these tended to be those institutes involved in relocation or reorganisation. Some degree of compensation was afforded by a number of other institutes achieving a better result than had been planned, central costs remaining within budget and savings and investments resulting in one-off positive results.

TNO has, however, completely achieved its objectives for turnover for 2000. This is gratifying, partly because it is a measure of TNO's impact on society and thus the effectiveness of TNO's use of available government funding.

The disappointing total result for the institutes meant that, in line with agreements, it was unfortunately not possible to pay a profit share to staff over the year 2000. As a result of the picture outlined above, extra attention





E.I.L.D.G. Margherita, M.Sc.

will be devoted within company operations where necessary to cost control, increased efficiency and the discontinuation of unprofitable activities.

Major investments in buildings have clearly reduced TNO's liquidity, a matter that requires attention, which will typically take the form of action to make more effective use of working capital and introduce a sober investment policy for 2001 and successive years.

Following studies into the capital requirements of the Dutch universities, research into the capital requirements of TNO was carried out. The outcome was that, as things now stand, funds are insufficient to carry through the current strategy and future plans. Further discussion about this with the government has already started. Government funding remained, by and large, stable.

### Personnel

For an organisation such as TNO, the most important success factor is the employees and what they bring to the organisation: their originality, inspiration and client contacts. For this reason, TNO devotes increasing attention to the recruitment, loyalty and development of its employees.

The total number of employees in 2000 rose from 5130 to 5180. In line with plans, 621 new colleagues joined us. The number of colleagues leaving was higher than expected at 587. The attractiveness of TNO as an employer has grown, especially as the first employer of recent graduates. In the authoritative KPMG/Universum Top 20 for attractive first employers in the Netherlands, TNO rose during 2000 from 17th to 7th place. Socially and technically relevant work, as the next step after a scientific education, clearly appeals to the current generation of starters. In general, TNO has been able to fill its vacancies, although ICT, in keeping with the general market trend, proved an exception to the rule.

figure 1 – TNO 's turnover

total 2000 € 449 million (TNO excl. TMB) – in percentages



figure 2 – Market turnover

total 2000 € 295 million (TNO excl. TMB) – in percentages

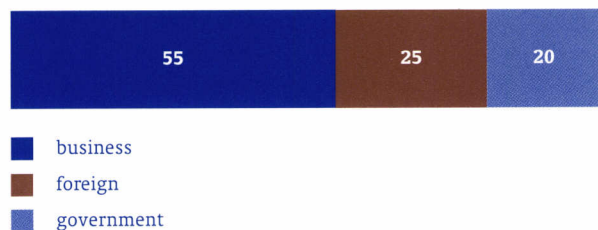


figure 3 – Foreign turnover

total 2000 € 74 million (TNO excl. TMB) – in percentages



The outflow of personnel in 2000 was 11.4%, a little higher than planned. It appears from internal surveys that the desired and undesired outflow was well balanced. TNO is certainly excellent at recruiting; retaining personnel requires extra attention.

In 2000 two TNO staff were appointed Senior Research Fellow (SRF). Dr Paulien Bongers for her groundbreaking work into the causes of and solutions for Repetitive Strain Injuries (RSI), and Dr Joop van Hemmen who received recognition for his great services to the study of the influence of chemical substances on the human body.

The TNO Service Recognition Award was bestowed on three colleagues at the start of 2001: Martin Scholten received it for his scientific and good entrepreneurial work on ecological risks, Jan Jetten for his work in extending the position of TNO in the field of carbohydrate technology and Gerard Dingjan in acknowledgement of the way in which he has stimulated business thinking within TNO over a great many years.

## Markets

TNO's consolidated market turnover in 2000 rose to € 325.3 million (9.9% up on 1999), in line with strategic objectives. Activities within TNO are divided into 14 core areas, which enables TNO to strive for a good market focus and match. In four of the core areas – product development, electronic and physical systems, nutrition and work – TNO achieved above average growth in 2000.

As well as the core areas, the business centres also provide important portals to the market via which the combined expertise of different institutes can be offered. They are a necessary complement within the TNO organisation and foster TNO's market interests. There are now nine such centres. TNO's increasing market focus is also apparent from the growing number of institutes now working with account managers or business directors, who fulfil a useful linking role between the TNO organisation and client interests.

### The nine business centres:

- TNO SME
- TNO Soil and Sediment Remediation Research
- TNO Chemistry
- TNO Social Safety
- TNO Multimedia and Telecommunications
- TNO Pharma
- TNO Space
- TNO Traffic and Transport
- TNO Ageing Research

The activities of the various institutes for the SME segment have increased, encompassing both development work for innovative businesses as well as the transfer of existing knowledge to individual businesses, sectors and business chains. The successful TNO SME Initiative, which helps businesses to formulate their strategy, is being incorporated within the general incentive regulation by the Ministry of Economic Affairs. It makes sense to ensure that the essence – good supervision – is maintained. Since 1997 target funding by the Ministry of Economic Affairs has taken place via a co-financing mechanism. Following an introductory period this regulation has grown to become a great success.

The total volume of co-financing in 2000 was € 25.5 million. The incentive mechanism has inspired the business community to initiate many real innovative developments. The longstanding collaboration between TNO and major companies such as ASML, Unilever, DSM, Stork and many others was strengthened in 2000. These strategic collaborative partnerships can reveal significant value for the client, as is apparent from the number of successful development projects. TNO has set itself the goal of entering into more collaborative partnerships that offer the client appreciable added value, and this fits in extremely well with TNO's mission. In the Netherlands there are four so-called Top

Institutes in technology. TNO participates in each of these and subscribes wholeheartedly to the principle that marked the setting up of these top institutes, namely a close collaboration between business, universities and knowledge institutes for the creation and implementation of a programme for pre-competitive research.

TNO's foreign turnover reached € 74 million. The number of partnerships with major foreign parties is increasing. This applies to both companies and organisations, including the European Space Agency (ESA). One key resource in stimulating this kind of collaboration is the EU Framework Programme.

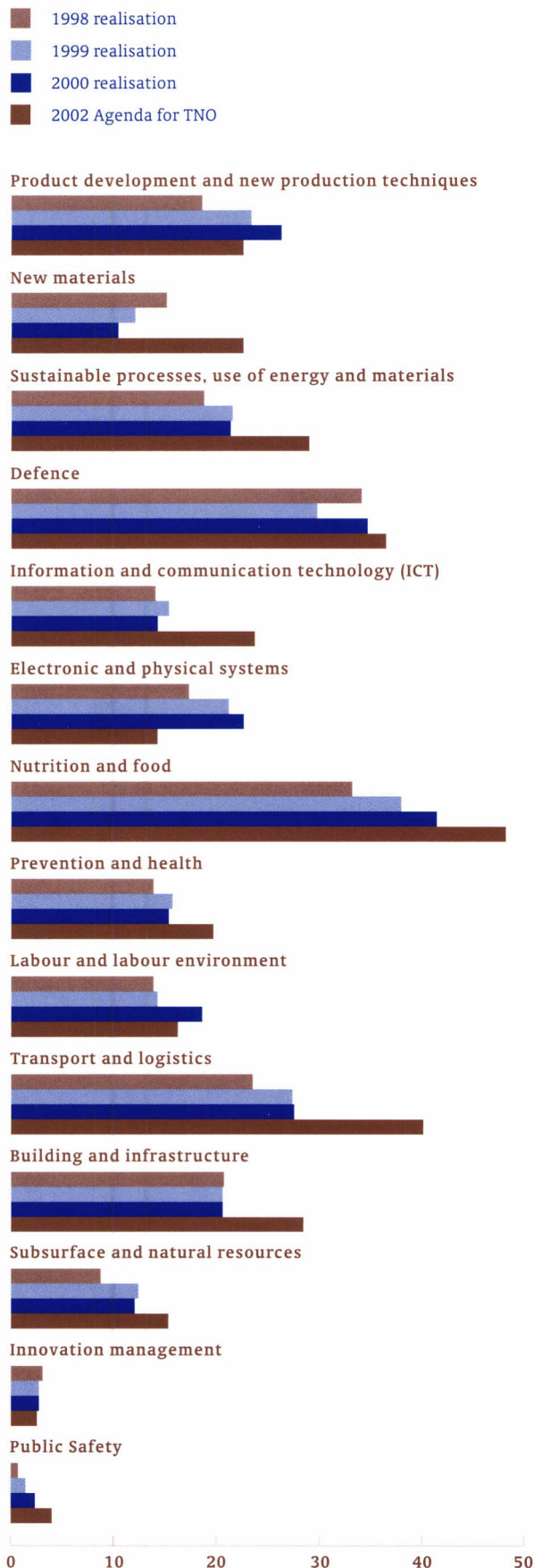
## Development in core areas

Figure 4 illustrates trends in TNO's market turnover and turnover per core area.

### Product development and new production techniques

The rise in turnover in this core area was roughly 17% compared with 1999. Technologies, electronics, micro-system technology and rapid prototyping in particular showed strong growth. The technology position audit motivated the re-formulation and combining of the technology portfolio; action on the marketing front should reinforce activities pertaining to food processing

figure 4– **Market turnover by core area**  
(excl. intra-company assignments and government  
funding) – millions of euros

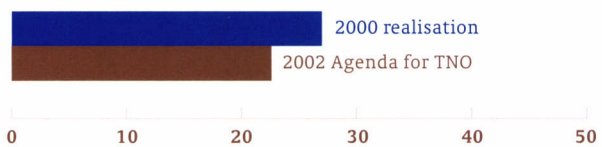


equipment and packaging. The relationship with the Netherlands Institute for Metals Research (NIMR) top institute clearly improved.

The strategic collaboration with ASML in the development of new wafer steppers was intensified, with activities extending to include precision cleaning: the analysis and prevention of surface contamination by (sub)micron particles and ‘airborne’ molecular contamination.

‘Value management’ is taking off in the market. This is a technique for analysing corporate product portfolios and for making recommendations for product improvement and updating. A link to tools for ‘road mapping’ in which, together with product updating, a business’s technology requirements are also assessed, is at the planning stage.

**Product development and new production techniques**  
– millions of euros



There are signs that mass individualisation can count on attracting great interest. This development is in full swing in services and software products, but physical products is the area in which the challenge to deliver made-to-measure services for an ‘off-the-peg’ price is greatest. What is more, it must be ensured that comfort and client perception are taken in account during the design process.

TNO began research into preventing ‘metal dusting’, damage to metal process equipment by process gases at high temperatures. Participants in this research include an American network, the University of Technology Eindhoven (TUE), the University of Technology Magdeburg and the Karl Winnacker Institut der Dechema in Frankfurt, Germany. In total, 25 businesses from around the world are involved in the project.

#### New materials

The market turnover for new materials fell slightly by comparison with the previous year. This was partly caused by the relocation to the new building in Eindhoven. Foreign turnover showed a clear increase, despite the difficult collaboration with the Institut für Neue Materialien in Saarbrücken in the European Centre for Product Innovation and Coatings (EPC). In 2000 the setting up of TNO Chemistry lent some weight to the idea of an integrated TNO-wide impact on the market. It will certainly have positive effects on turnover.

During the year under review TNO made an intensive contribution to the further development of photo-voltaic

(PV) solar energy. This research is conducted within the framework of Novem and Economy Ecology Technology (EET) projects in close collaboration with partners including Shell Solar Energy, Akzo Nobel and the Energie Centrum Nederland (ECN).

Together with a manufacturer of automatic transmissions, TNO gave impetus to the development of a new generation of products. In this work TNO has made use of test facilities for the measurement of wear-and-tear by sustained sliding contact between materials. This facility, which is unique in Europe, is attracting a great deal of foreign interest.

#### New materials

– millions of euros



The Marine Materials Laboratory (MML) in Den Helder collaborated with TNO on responding to the problem of corrosion on large offshore installations. This damage research is part of a structural approach to the problem of corrosion on large installations at sea.

The growing number of possibilities for the application of semi-conducting polymers in plastic electronics prompted further growth which was supplemented by bilateral projects in this area, such as that with Philips. For the Department of Public Works and Water Management, TNO determined the remaining life of rubber seals in the sluices of the dike in Oosterschelde, part of the Delta Works in the south west of the Netherlands. This enabled the client to postpone a large-scale and extremely expensive replacement operation and implement an improved maintenance plan instead.

#### Sustainable processes, use of energy and materials

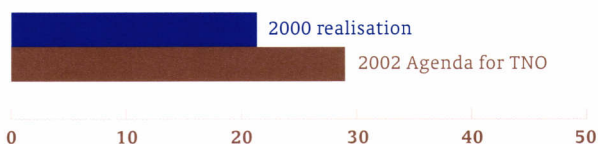
Following considerable growth in 1999 the market turnover stabilised in 2000. Nevertheless TNO was able to achieve clear growth in turnover in the programmes for Novem and the Economy Ecology Technology (EET) programme. The organisation strives for a stronger role as a process innovator, for example in the fields of process control, safety and the use of water for the animal foods sector and fine chemistry. Furthermore, a consortium for the development of technology and instruments for smaller scale, more flexible and more efficient production processes expanded to include more than ten fine chemicals businesses.

In addition, TNO strives for a role as a system innovator for all parties involved in, for example, chain concepts, sustainable industrial locations, sustainable cities and

recycling in the construction industry. One example of this is a large in situ soil remediation project at DAF, carried out with Grontmij, NBM-Amstelland and the SKB (the Foundation for Soil Knowledge Development and Transfer). TNO's role as system innovator is also expressed in a project to do with the completion of the construction materials chain. This involves processors of construction and demolition waste, cement manufacturer ENCI and brick foundries. Together with these partners TNO is developing and implementing processes in which construction waste can be used as the raw material for the production of cement and bricks.

#### Sustainable processes, use of energy and materials

– millions of euros



The winning of the NIDO Srongprijs award by TNO signals a nice achievement in the field of innovation in town planning and design. Amongst some 300 suggestions, 'The Values of Water' came out on top as the best sustainable project. It attributes various valuable roles to water in the city, for example for recreation, as a heat buffer, a transport medium and a biomass production resource. Getting the right combination of these roles makes it possible to provide a very sustainable city water system. The prize money of € 0.5 million finances work with parties in the market to prepare the idea for implementation.

#### Defence

Market turnover grew by 9%. Further developments in the core area will be heavily influenced by the stabilisation of target funding and modest growth in additional financed research. Good progress is being made with the introduction of programme financing.

#### Defence

– millions of euros



Research associated with the formulation of Defence policy was an area that demanded extra attention. A thorough inventory of the Ministry of Defence's research requirement showed that a considerably greater need exists than can be covered by existing resources. This has resulted in pressure on budgets, difficult choices and changes to research motivated by necessity.

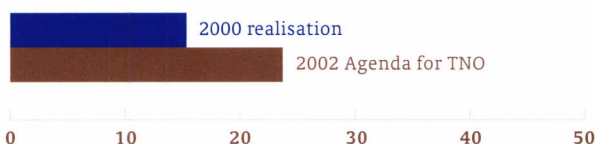
The complexity of the problems within the armed forces is increasing. Adequate support by analyses, modelling and simulation are essential to proper functioning. In any event, modelling and simulation are really taking off. This has inspired an initiative for TNO-wide activity in this field.

Education and training is a priority area that deserves considerable attention over the coming years. Other areas similarly demand intensive support. For example, protection against chemical and biological threats, effective leadership, the introduction of new frigates, armoured vehicles and fighter planes and the optimal use of information and communication technology.

#### Information and communication technology

The accumulation of turnover progressed somewhat disappointingly in 2000; the sharp upward trend of the preceding years could not be maintained. The areas of telecommunication, embedded systems, safety, multimedia and human factors did, however, demonstrate a strong rise in turnover. The disappointing picture as a whole can be partly explained by the overstretched employment market, which frustrated the anticipated growth in personnel.

#### Information and communication technology (ICT) – millions of euros



TNO would like to reinforce its role in the field of ICT use within business and government. Basic funding from the Board of Management financed the start-up of major new projects in the field of distance learning, information security and multimedia applications, thereby lending substance to our aim. The Multimedia knowledge centre, a collaboration with the University of Amsterdam, was launched. In time these initiatives should have a positive effect on market turnover. The start of the TNO-wide target funding theme 'ICT and the government' will also exert a favourable influence on the position of the core area within TNO. It focuses on the knowledge requirements of the ministries of Housing, Spatial Planning and Environment, Social Affairs and Employment and Public Health, Welfare and Sport.

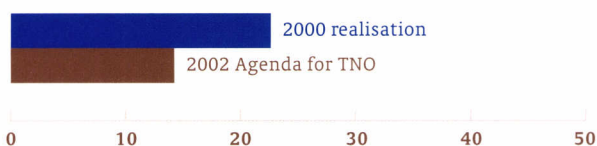
The start of a TNO branch in Silicon Valley signals a key initiative. Furthermore, TNO opened a branch in Enschede focusing on 'networked business' and TNO became a partner in the Kenniswijk Eindhoven (an urban digital knowledge zone). A considerable amount of TNO programming took place within the Telematics

Institute, thanks in part to GigaPort. Points of special interest were the making of multimedia information accessible via Internet and security and payments involved in e-commerce. The transparency surrounding the demand and supply of knowledge were emphatically on the agenda of the Ministry of Economic Affairs' Taskforce ICT in which TNO participated.

#### Electronic and physical systems

Within this core area continued growth in market turnover is evident: the objectives for 2002 have already been far exceeded. In particular, TNO did well in the area of optical instrumentation for Earth observation and space travel, process optimisation and control, electronics and embedded systems. A couple of major basic financing projects in this area are important to maintaining growth in turnover. Specific areas worthy of attention are high resolution X-ray detection, techniques for measuring aerosols in the atmosphere and soil classification using sonar techniques.

#### Electronic and physical systems – millions of euros



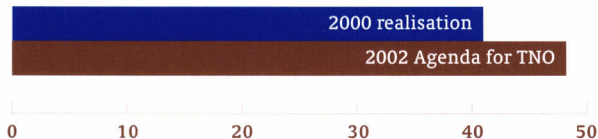
Strategic collaboration with ASML grew closer in 2000; TNO signed an agreement with ASML and Carl Zeiss for research into the new generation of lithography machines. TNO's contribution will include work on system engineering and its opto-mechanical design. The imminent launch of the Aperture Synthesis knowledge centre, a collaborative partnership with the TU Delft, is of great importance in safeguarding TNO's position in Earth observation and space travel. Strong aspects of this area are Earth observation, solar sensors and radiometric calibration. Our knowledge position in these areas has formed the basis for participation in projects such as GOME-2, Sciamachy and OMI. The European Space Agency (ESA) successfully launched some cluster satellites that contained 'starmappers' developed by TNO.

#### Nutrition and food

The market turnover in the area of nutrition and food is increasing rapidly. The year 2000, with a growth of 10%, almost entirely due to demand from abroad, was no exception. TNO BIBRA in England took shape in the course of the year. TNO played an important role at the start of the European SAFE project which successfully lent weight to the expectation that SAFE can provide the impetus for the establishment of a European organisation for food safety.

'Nutrigenomics' is the new challenge facing nutrition scientists. TNO plays a leading role in this field, thanks in part to its coordination of the first nutrigenomics programme by the European Union. TNO combines an integrated 'functional genomics' facility for the production of DNA arrays with a proteomics group and bio-information activities. This enables TNO to focus on new functional foods, safety evaluations, biomarkers and genotyping.

**Nutrition and food**  
– millions of euros



Allergy research, in which TNO collaborates with the Utrecht Medical Centre, deserves special mention. The number of allergy cases appears to be on the increase and TNO's aim is to be able to predict the chance of new, genetically modified foods that cause an allergic reaction. Gathering more knowledge about this field is crucial, whether or not an allergy does occur, as is the determination of the threshold value for an allergic reaction and the clinical consequences of this. A new, validated oral animal testing model makes it possible to predict possible human reactions.

**Prevention and health**

Market turnover stabilised in the core area of prevention and health as a result of the transfer of the radiation research to the Interfaculty Reactor Institute of the Delft University of Technology. Collaboration with the university infrastructure is essential in this core area if the market is to be exploited. In 2000 this collaboration was, in any event, further reinforced by agreements with the Vrije Universiteit (VU) in Amsterdam for collaboration in the area of cardio-vascular research. Following preparatory work in 2000, TNO and the VU will set up a knowledge centre for 'Healthy Movement'. Furthermore, structural collaboration with the Leiden University Medical Centre (LUMC) in the area of rheumatism and vascular medicine is almost complete.

**Prevention and health**  
– millions of euros



The private market saw new initiatives in medical technology and medical information that afford TNO a stronger position. In the pharmaceuticals market,

some is stabilising, but in sectors such as obstetrics and prenatal care, market growth exceeded expectations. Investments in innovative knowledge developments are already bearing fruit.

From now on, in the market area of health care management TNO will concentrate on Health Technology Assessment (HTA) within care and on medical resources.

In addition to existing companies such as TNO Certification Medical Devices, significant attention was paid to preparations for new life sciences enterprises that will enable TNO to commercialise its knowledge and knowledge products in the most effective way possible. This also serves to reinforce TNO's strategic position in those market segments that are already strong.

**Labour and labour environment**

This core area that focuses on work and working conditions showed a growth in market turnover of a good 25%. This was largely thanks to activities in the area of safety management, reintegration and ergonomic innovation. Contracts from both Dutch companies and institutions as well as from the Dutch government and international organisations contributed to this. The Ministry of Social Affairs and Employment remains an important client, both in the field of reintegration as well as in relation to the health and safety knowledge infrastructure.

**Labour and labour environment**  
– millions of euros



An important contract within the Fifth Framework Programme of the European Commission is about optimisation of assembly processes. Participants include Volvo and Fiat. On this extensive project TNO is working together with European colleague institutes.

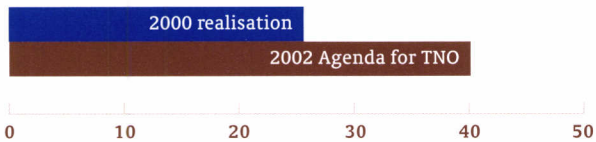
Socially relevant activities in the area of reintegration occupy an increasingly important position. Thus TNO is closely involved in the Expertise Claim Assessment and is developing knowledge and products in this area together with the University of Amsterdam. Other fields showing an increasing turnover are RSI, work pressure as well as health and safety knowledge infrastructure.

**Transport and logistics**

Stabilisation in market turnover for transport and logistics breaks the pattern of the strong increase of previous years. The most important explanation for this is the disappointing international turnover in the automotive field. Action is being taken to get the growth back on

track, such as reinforcing the TNO Traffic and Transport initiative. The intensification of market initiatives, in particular, garnered attention, including the area of intelligent transport systems and transport safety. New offices in France and Germany are focusing on the sale of the MADYMO crash simulation software, advanced engineering services and crash tests.

**Transport en logistics**  
– millions of euros



TNO's collaboration with the research school TRAIL, a collaborative partnership by the TU Delft, the Erasmus University of Rotterdam and the University of Groningen got off to a good start in 2000, while intensive collaboration also took place with the Connekt knowledge centre. TNO participated in an initiative by the Ministry of Economic Affairs to develop the profile of the Dutch automobile sector. In this way, TNO is striving for far-reaching collaboration with universities and market parties and is concentrating on spearhead technologies that are likely to be successful.

The recently developed field of Advanced Transport Systems, with its core theme of automatic vehicle guidance, developed according to plan in terms of both the development of knowledge and its market position. TNO is involved in virtually all the national initiatives and is also represented in the international marketplace. An advanced 'hardware-in-the-loop' test facility for automatic vehicle guidance systems should boost the possibilities in time.

For Railforum Nederland, TNO contributed to much debated research into automatic trains, while also working on a concept for automatically guided rail buses for 'unprofitable' lines. Research into the technological possibilities of the 'kilometre toll' system underpins the parliamentary decision-making process. TNO also developed a strategic transport plan for the Flemish authorities and the subject of a research project for a large car manufacturer was a lower visual workload for advanced cruise controls.

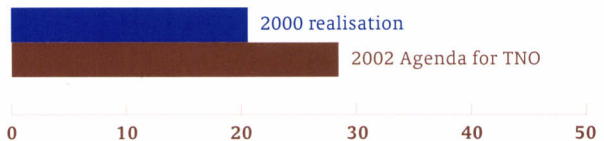
**Building and infrastructure**

While the market turnover for building and infrastructure remained stable, a slight rise in turnover was detectable among foreign clients. The Building and Systems knowledge centre, a collaboration with the Technological University of Eindhoven (TUE), started up again, taking advantage of the increasing demand for systems and system integration in the construction industry.

Installation techniques are quite well integrated in modern buildings. Energy saving and the creation of a safe and healthy indoor climate are special areas of interest, so intelligent combinations of installation components are required. TNO capitalises on this system approach by providing simulation possibilities for installations, development platforms for operating software and comprehensive product development.

In the west of the Netherlands a delta metropolis is rapidly emerging. This means that builders of high-speed lines and tunnels are confronted time and again with new knowledge issues relating to the governmental decision-making process on routes, the way in which money should be spent and safety issues. The technical risks involved in building in and on weak ground remain a key issue. It has prompted TNO, together with four Delft research institutes, to develop the Delft Cluster integrated knowledge base.

**Building and infrastructure**  
– millions of euros

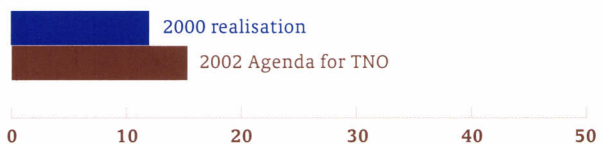


Management and renovation are significant aspects of construction work. An empirical, practical approach towards maintenance is no longer sufficient and is making way for a more technical underpinning involving status reports and systematic maintenance. This modern maintenance requires an understanding of what takes place within materials and that this understanding be made measurable. This is done by ascertaining the biological and bacterial damage done to materials, long-term degradation characteristics in monuments and the use of sound, radar and magnetic nuclear spin resonance.

**Subsurface and natural resources**

The market turnover for this core area, which provides geoscientific information and research, stabilised. The completion of the merger process within the Netherlands Institute of Applied Geosciences TNO – *National Geological Survey* was marked by the two main functions becoming operational in terms of planning, control and finance.

**Subsurfaces and natural resources**  
– millions of euros



Just one last step remains: the move to the new head office in Utrecht, linked to the Faculty of Earth Sciences at the University of Utrecht. Building commenced at the end of 2000 and will be ready midway through 2002.

In the year under review, geoscience knowledge centres with the Vrije Universiteit and the TU Delft were formally launched.

A large number of synergetic and complementary agreements have been finalised. They form the basis for optimising the collaboration with other public knowledge institutes in the Netherlands.

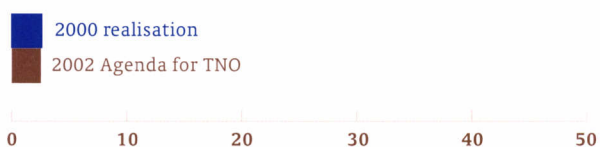
Colleagues from TNO and a University of Utrecht foundation formed a new research group, whose chief activity is to carry out applied research and give complex geo-advice about the Paleocene environment. This specific expertise is relevant to both the shallow and deep subsurface.

Despite problematic financial conditions, projects have been secured that focus on the institutional reinforcement of knowledge institutes in developing countries. As part of this, a geoscientific project has been carried out in Paraguay in close collaboration with a sister institute in Asunción.

### Innovation management

Innovation management experienced stable market turnover, at roughly the same level as in 1999. The focus lay on the further positioning of TNO in the area of innovating, strategic research into the influence technology has on society, the government, business and vice versa. TNO aims to use this project to contribute to an innovative economy and to a sustainable, knowledge-intensive society. The core area of innovation management is coupled to the sciences, necessary for the desired change, regeneration and successful application of new technology.

#### Innovation management – millions of euros



One tangible example of this is an international project in which the researchers, together with colleagues in England and at the Telematics Insitutute, are investigating how e-commerce is influencing the market structure. As part of their work they are systematically mapping factors for success and failure. Together with NIVE (the Netherlands Association for Management), TNO is applying itself to the question of what form 'leadership' is likely to take, in the light of economic growth and sustainable development. For the steering committee

on Innovation Focused Research Programmes (IOP), and as preparation for public projects, TNO carried out a preliminary study for the genomics research programme. The steering committee took on board the positive recommendation with its implied budget and the three proposed research themes. In the meantime the programme is underway, with the participation and great enthusiasm of the business community and knowledge infrastructure.

### Public Safety

The growth of the market turnover in this core area is in line with the strategic plan. The reporting year was characterised by the reinforcement of the strategic position with the Ministry of Home Affairs, the police and the fire brigade. The Ministry and TNO are working on the structural development of a research relationship by, for example, making an inventory of the Ministry's knowledge requirement and the technology offered by TNO. TNO is now recognised by the police and fire brigade as a knowledge supplier, especially in the area of computer systems for training and in supporting decision-making.

#### Public safety – millions of euros



The fireworks disaster in Enschede has played a prominent role in the research. Attention was also devoted to other areas of attention: camera surveillance, the use of pepper spray and teargas, the flow of passengers at Amsterdam's Schiphol international airport, the transport of documents and the explosion resistance of embassies.

### Knowledge development

For an organisation like TNO, which focuses on knowledge development, it is very important that access to fundamental knowledge development continues. Since this process primarily takes place in the Netherlands within the universities, TNO pays a lot of attention to collaborating with these institutions in partnerships that tend to run smoothly. New buildings for three TNO institutes will be appearing on university campuses and the number of knowledge centres has risen to 24. These centres are collaborative partnerships in which, as a rule, each party – the university and TNO – covers half the personnel and financial costs. Together they develop new knowledge that is interesting for both the university and for TNO.



The Lorentz-Van Iterson Fund, which funds TNO professorial chairs, also meets a need felt by both the universities and TNO. Measures have been taken to formally guarantee the level of these TNO professorial chairs. Across TNO as a whole, the application of resources intended for the development of knowledge are being more closely focused on genuine knowledge development and market development through keeping anticipated results firmly in mind. This applies just as well to market turnover, patents and publications as it does to concrete market positions.

A resource that lends this system form is the practice of internal TNO tender. This stimulates collaborative partnerships between two or more institutes, with the aim of initiating really innovative projects. Project assessment is based on quality and tangible results. A sum of € 4.5 million has been set aside for this procedure and it is already regarded as a success. Over the coming years, the amount will rise to € 13.6 million.

### The commercialisation of knowledge

An integral part of TNO's mission is to commercialise knowledge. This involves knowledge that TNO possesses and develops for the benefit of society and usually implies the selling of expertise to private parties for commercial consideration via projects.

If no partner for the commercialisation of knowledge can be found, and TNO is still convinced of the potential of the innovation, TNO can set itself up as a company or participate in a company. It is always clear from the outset that the activity can be abandoned at any time. The companies under TNO Management B.V. (TMB), TNO Beheer B.V. and the TNO Startersfonds B.V. are thus for TNO the ultimate form of selling knowledge. TMB is a channel for TNO to supply the market with technology that is not only technical, but also commercially proven.

TNO lays great emphasis on the active and commercially responsible management of its portfolio of companies. This has motivated a considerable number of changes in the portfolio during 2000. On balance the number of companies involved has increased and there was also a marked rise in consolidated turnover.

TMB, and the limited companies incorporated within it, does not operate as a venture capitalist. It seeks profit and the long-term coverage of losses is not appropriate. The attainment of a certain return within a particular predetermined period is not the sole criterion by which a decision is taken on whether activities are started. The principal objectives are putting the knowledge to work and the creation of continuity for the application. In fact, this boils down to the creation of new, high

quality employment; the new companies have to be able to eventually pay their way and grow into attractive candidates for take over by private parties.

It is perfectly normal for any new start-up to have to deal with losses in its early stages. TNO's plan is to finance these losses from the sale of interests in companies that have reached maturity. If all goes well, the invested capital more than pays for itself eventually. This ensures an appreciation in value that, in turn, makes new initiatives possible. The goal is to achieve a modest positive result while balancing investment, sale and acquisition. During 2000 this result amounted to roughly € 0.8 million.

The historical long-term result shows that TMB has successfully adopted this growth mechanism. In fact, over the last ten years the return on invested capital has reached 10% annually. The goal for the future is to steadily continue to apply this mechanism for growth and, if possible, to reinforce it.

A key component of the capturing and commercialising of knowledge is patenting. The possession of patents increases TNO's power to attract potential clients and can lead to income from licences. For some years now, attention has been paid systematically to the localisation and elaboration of knowledge that is suitable for patenting. This falls within the responsibilities of the Patents & Licensing department. The number of patentable inventions has risen in recent times from 30 to 160 per year.

#### 2000:

– internally registered inventions	160
– total patents (end 2000)	671
– total patents filed (end 2000)	1042
– total inventions (end 2000)	404

### Quality

TNO has an extensive and properly functioning quality and audit system. Nearly all TNO institutes have ISO 9001 certification and during 2001 this will be attained for TNO as a whole. The laboratories and places of work to which this will apply adhere to Good Laboratory Practices (GLP) and work according to the Sterlab requirements.

Once every three years an employee satisfaction audit is held involving all staff. With the same frequency, each institute conducts a customer satisfaction audit. The important technology position audit (TPA), in which a small, high-level International Audit Commission analyses the knowledge level and the market relevance of a group

of TNO technologies, appears in practice to be a very important resource for determining the direction the organisation should take. TNO is extremely grateful to the members of the Audit Commissions. In 2000 the full cycle of TPAs was completed. For each audit, the recommendations lead to the creation and execution of improvement strategies. A distinct rise in the level of technology as compared with the findings of the previous audit cycle has been confirmed. Nearly all technologies are national leaders in the level they have reached.

Although the number of technologies with which TNO occupies a 'world position' is increasing, a further rise remains an important feature in the plans. In recent years the number of technologies over which TNO's technology position is divided and in which TNO is active has been reduced from roughly 400 to 218. This is due to technologies being combined and to TNO putting a stop to activities that are no longer attractive.

## Ethics

The internal platform Ethics and Research is drafting a company code, which will become part of the strategy for the coming period. The concept will be discussed within the organisation and after due consideration will be adopted. The valuable contributions of the Medical Ethics Commission and the Animal Experiments Commission meant that TNO was able to maintain guaranteed high standards in its working methods.

## Collaboration nationwide

Within the Dutch knowledge infrastructure there exists a close-knit network of project and programme oriented collaborations. The knowledge centres with the universities are a good example of this. TNO also works frequently with other Dutch knowledge institutes on projects. These collaborations are sometimes long term, as they are with the top institutes and in the collaborative partnerships in public projects. Since the balance sheet date Holland Metrology (HM), the parent organisation of NMi, the Netherlands Institute for Metrology and Technology, has become legally incorporated within TNO, which has held the organisation's economic property rights since 1 July 2000. HM's results have been incorporated into TNO's figures since this date. Current joint initiatives confirm the conviction that the inclusion of NMi within TNO will deliver very positive results for the NMi and for other subdivisions of TNO.

A collaboration with the Maritime Research Institute Netherlands (MARIN) has been set up. The Ministry for

Economic Affairs has commissioned an investigation to determine whether this collaboration will be further intensified and institutionalised. The combination of MARIN's hydrodynamic knowledge and the knowledge of shipbuilding and shipping that exists within various divisions of TNO can offer mutual clients interesting solutions.

A growing collaboration is developing with Wageningen University and Research Centre (WUR). One concrete expression of this is a joint venture in the field of research into animal foodstuffs. Furthermore, closer collaboration with other divisions of WUR and TNO can be realised.

In general, TNO looks favourably on initiatives to foster closer collaboration. TNO is fully supportive of efforts to avoid the disintegration of the knowledge structure and to thereby reinforce synergies.

## International collaboration

Within Europe the realisation is growing that a strong integration of the research activities in the various European countries is necessary to keep competition from Japan and the United States in the field of innovation at bay. The report on the European Research Area by the Eurocommissioner Busquin signals clear progress in this field. TNO fully supports the vision formulated in this report, both directly and via the European Association of Research and Technology Organisations (EARTO). The European Fifth Framework Programme is a key facilitator of closer collaboration. The main features of the improvement that have been proposed as part of the preparations for the forthcoming Sixth Framework Programme appeal to TNO.

However, other actions and initiatives alongside the Framework Programme are required to reach the goal. In various fields TNO is trying to actively contribute. One example is the SAFE consortium, which INRA (France), IFR (Great Britain), TNO, WUR and VTT (Finland) want to see grow into a European centre for food safety.

The European dimension is evident not only within the knowledge infrastructure. Many of TNO's clients are international and require support that has an international character, in terms of both geography and level. Furthermore, it is often important for national clients that the knowledge supplier has international contacts and experience. All this stimulates TNO to extend its international collaboration. In practice, this is not simple to achieve this beyond a project and programme level. This is due to the frequently national orientation of the European knowledge institutes. Nevertheless TNO continues to work towards more far-reaching forms of international collaboration.

Some smaller collaborative partnerships have already been formed. The nutrition institute TNO BIBRA in England marks a step in a direction with which TNO thinks that it contributes to a strengthening of the European knowledge infrastructure.

Whatever happens, the subject of internationalisation will remain a theme of strategic importance on the agenda. Growth by means of far-reaching collaboration with foreign parties remains the aim, however difficult that appears to be.

### Trusted third parties

Across the whole world, and certainly within Europe, a great and ever increasing need among citizens and the community exists for reliable, independent organisations. The collaborative partnership SAFE is one such organisation.

Recent crises and disasters highlight the need for action. Citizens need genuine, independent scientifically advanced responses to their questions. This is true for food safety, dangers of explosion and fire and social safety. The number of candidates who can fulfil the role of 'trusted third party' is limited. Such an independent role can barely be expected of fully private parties and both the government and governmental organisations are, as interested parties in many issues, not the appropriate players to assume this role. TNO is eminently suited to this role. TNO's legal position guarantees its impartiality. In any event, this integrity of organisation and work are extremely important to TNO.

### Future

The general climate and value attributed to knowledge are currently auspicious worldwide. The economic situation in Europe still looks reasonable and the readiness to invest in knowledge development is present. Moreover, there are still a number of issues in society that require answers. TNO can contribute to the development of solutions in the Netherlands and abroad since the internationalisation of the knowledge market is set to continue.

This makes the approach adopted by TNO look favourable. A number of possibilities have recently become apparent which the organisation can exploit. This is true for both the market as well as for the knowledge structure. The realised growth in turnover already shows signs of this. The organisation has already undergone considerable development, though internal planning and financial resilience appear to have been less strong than in previous years. In any event, it will come as no surprise that improvement in precisely these aspects will be firmly taken in hand in 2001. In the coming year the execution of the current strategy will be the main spur for the management of the organisation. The objectives outlined in that strategy will be realised.

*Delft, 9 April 2001*

TNO Board of Management

*J.A. Dekker, M.Sc., chairman*

*F.Th. Gubbi, M.Sc., vice-chairman*

*Prof. Dr P. Folstar*

*E.I.L.D.G. Margherita, M.Sc.*

## Senior Research Fellows



**'Physical and psychological stress are key factors in RSI'**

When Dr Paulien Bongers was studying Environmental and Work Hygiene at the Agricultural University of Wageningen, her initial focus was environmental issues. However, her attention quickly shifted to working conditions and in 1984 she started her doctoral research, investigating the impact of jolts and vibrations on the health of taxi drivers. In 1990 Dr Bongers joined what was to become the Ergonomics department at TNO Work and Employment. Her attention concentrated on epidemiological research into symptoms and disorders in the locomotor apparatus – more specifically the causes of Repetitive Strain Injuries (RSI) and their solutions. She has led other research, also for the European Union, into the scope of the RSI problem throughout Europe. She now manages a team that focuses on providing both research and advice on the causes of RSI and back complaints as well as comprehensive solutions.

'The term 'mouse arm' is a little unfortunate because RSI is not caused just by working with the mouse and is not confined to arm complaints. A recent random survey revealed that one in five employees also had lasting or regular work-related neck, shoulder or arm complaints. But data on the cause and scope of RSI have been just as limited to date as the term 'mouse arm'. Analysis has shown that despite much effort having been made in respect of prevention and adjustment, there has been a conspicuous absence of scientific evidence. How do you weigh up the various risk factors and what levels of risk are important? These issues have not yet been specified.

'In a large-scale, five-year long research project for the ministries of Social Affairs and Employment and Health, Welfare and Sport as well as the National Institute of Social Insurance, we are now identifying the relationship between posture and movement at work and the effects on the back, neck, shoulder and arm. It is

a project we are undertaking together with Amsterdam's Vrije Universiteit.

'Our approach is based on bringing to light everything that has so far been underexposed by first measuring the risks in the actual working situation before examining the effects. A lot of research investigates both aspects at the same time, which can confuse cause and effect. We have also determined the risk factors outside work for the 1800 employees that we have been studying.

'In addition, we have taken account of other factors that may be influential at work, like pressure of work and the organisation of tasks. In respect of neck complaints, it is clear that pressure of work is as much a factor as working for long periods with a bent neck or in a seated posture. The neck muscles make no distinction between the strain of poor posture or work tension.'



### 'Interest in exposure is growing fast'

Dr. Joop van Hemmen studied at the 'Vrije Universiteit' in Amsterdam, where he majored in chemistry. His own interest for processes in the human body led him to further studies in Biochemistry at the University of Leiden following his graduation. It was during his military detachment in 1967 that he first came into contact with TNO at the Medical Biological Laboratory in Rijswijk. Three years later he started working at TNO. He gained his doctorate in radiation chemistry and then worked in this field for six months at the Cancer Research Campaign in London. He heads the Exposure Research department at TNO Nutrition and Food Research.

'Exposure research is as crucial a component of risk assessment as toxicology. It's not merely a question of whether a substance is toxic, but whether it is present in someone's vicinity and the extent to which that person comes into contact with it. This is what enables you to make a real risk assessment. This connection has prompted close collaboration with the Toxicology Risk Assessment department.

'We carry out industrial toxicology research for the Ministry of Social Affairs and Employment and for the chemical industry. What happens to employees that are exposed to industrial chemicals, pesticides or biocides at work? To answer this question is largely a matter of developing and applying methods for dosage response relationships and of risk assessment and management. The government obviously has its duty to ensure that the health risk to employees is kept as low as possible. The art is to bring that exposure down to its lowest possible level in a scientifically responsible way given the economic possibilities and restrictions.

'If we actually determine a risk as being too high, there are three responses we can make. Look for an alternative substance, take measures to reduce the exposure or even prohibit an activity in which a particular substance is used. This last option, especially for substances that have been used for a long time, is not very practicable. The normal response is to protect employees or improve the process. But there are substances that have been used and accepted for decades that do appear on the 'prohibited' list because we have come to understand the real risks.

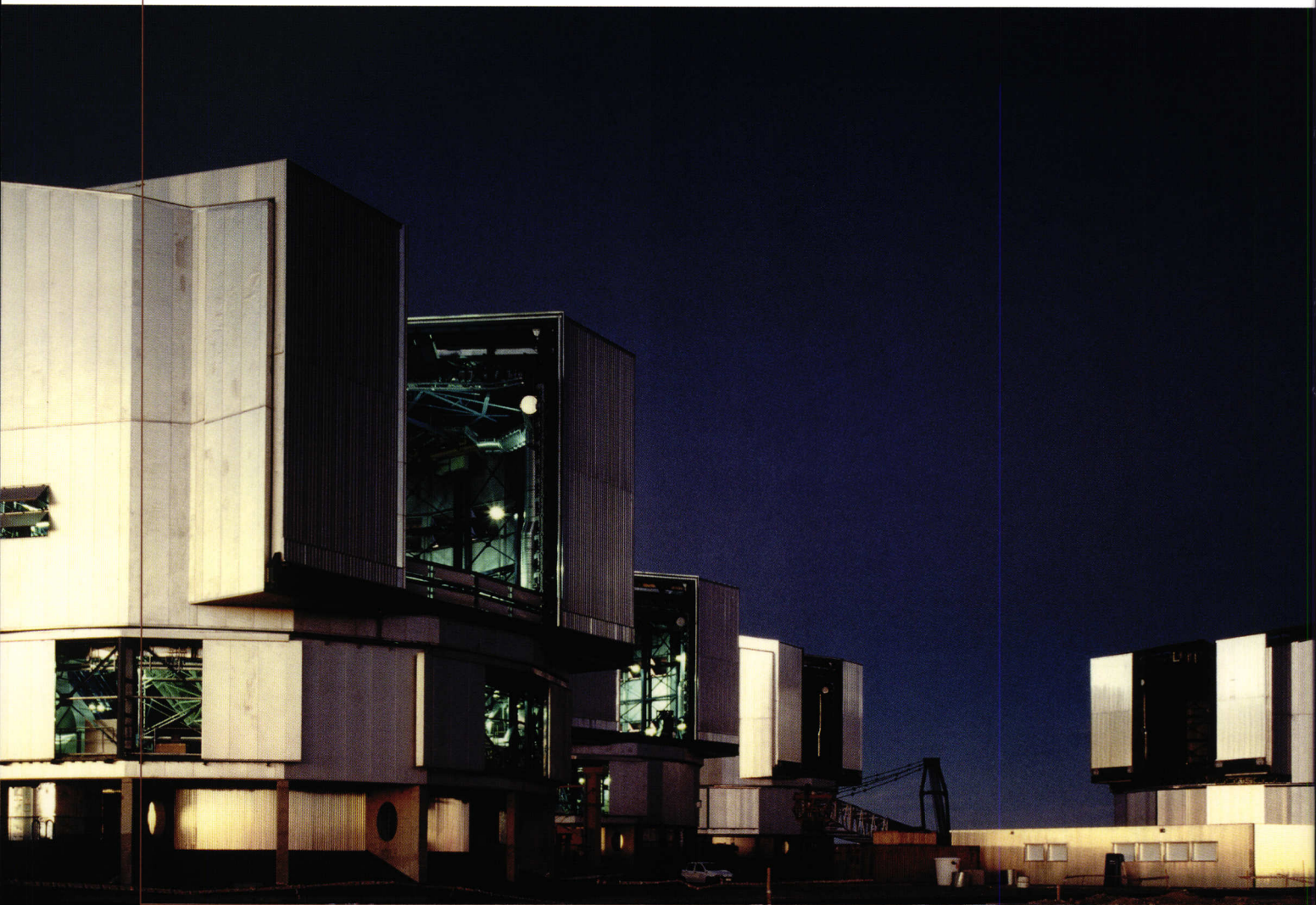
'According to the Ministry, we lead Europe in this kind of knowledge by a long way. We are currently responsible for coordinating European research that involves fifteen institutes from ten countries into skin exposure to industrial chemicals and the associated risk assessment. We are also coordinating a recently initiated research programme for biocides. It is one of our aims to work towards an effective and transparent assessment system for Europe.'





## TNO in practice

TNO is a corporate contract research organisation with a mission: to strengthen the capacity of business and government to innovate through the application of technological knowledge. It is this mission coupled to its position in the Dutch knowledge infrastructure that enables TNO to form a bridge between fundamental research and practical application. Core activities include the development and utilisation of knowledge for clients, the transfer of knowledge, particular to the small and medium-sized business sector, the provision of a 'principal, particularly' for the Ministry of Defence and the commercialisation of knowledge. 'TNO in practice' offers a selection of projects to illustrate these core activities.



Optical delay lines:

## Look, there's a man on the moon!

With its stable atmosphere and cloudless horizon, the summit of Cerro Paranal in Chile affords a clear view of space. Not surprising, therefore, that the European Southern Observatory (ESO) should

position here the four telescopes of the Very Large Telescope Array (VLT), each of which has a mirror of 8.2 metres in diameter. By combining the light of these and eight smaller telescopes, this is the largest optical telescope in the world. In fact, its optical resolution competes well with, for instance, a telescope with a diameter of 200 metres.



However, to make a single image from four telescopes is a very complex business. To obtain a coherent image, the route the light takes through the four telescopes to the coordination detector has to be the same, to a limit of ten nanometres. That is why the light has to be 'diverted' via eight optical delay lines that ensure that the light from a star covers exactly the same distance and therefore arrives at exactly the same moment on the coordination detector. A delay line comprises an extremely accurate retroreflector on a trolley that moves on sixty metres

of rails in a tunnel. Fokker Space and TNO are jointly responsible for the design and construction of this 'railway'. The first three rails and mirrors are already functioning, indeed exceeding expectations. Early in 2001 the first astronomical application of interferometry has enabled ESO to take pictures that can even show the movements of an astronaut on the moon.



TNO BIBRA:

## Genotyping for the pharmaceutical industry



TNO BIBRA in England offers a broad range of possibilities for pharmaceutical and foodstuffs research. In the area of foods, the emphasis lies on research into 'nutraceuticals', functional foods and food supplements. Specialisms within oral hygiene and dermatological research comprise a valuable complement to the services offered by TNO Pharma. In the recent past the Institute has carried out more than 50 clinical studies for the pharmaceutical industry. The possibilities include a complete series of phase I and phase II research, both for new and existing medicines.

One of TNO BIBRA's strengths is its database of 4,000 volunteers. A database of this size makes it possible to select specific populations for research, such as older people or those with kidney or liver disfunction. TNO BIBRA has recently established the genotype of a representative group of these volunteers. This is of great importance for clinical pharmaceutical research. The Institute now knows which genotype form of the enzymes CYP2D6, CYP2C19 and CYP2C9 each of these volunteers possesses. These Cytochrome P450 liver enzymes influence the process of metabolising medicines that are broken down in a better or indeed worse way depending on the various, genetically determined 'manifestations' of these enzymes. The possibility of selecting volunteers with a fast or slow metabolism increases the accuracy of research results and prepares the way for the development of medicines customised to individuals' needs.



Genomics:

## Investing in scientific breakthrough

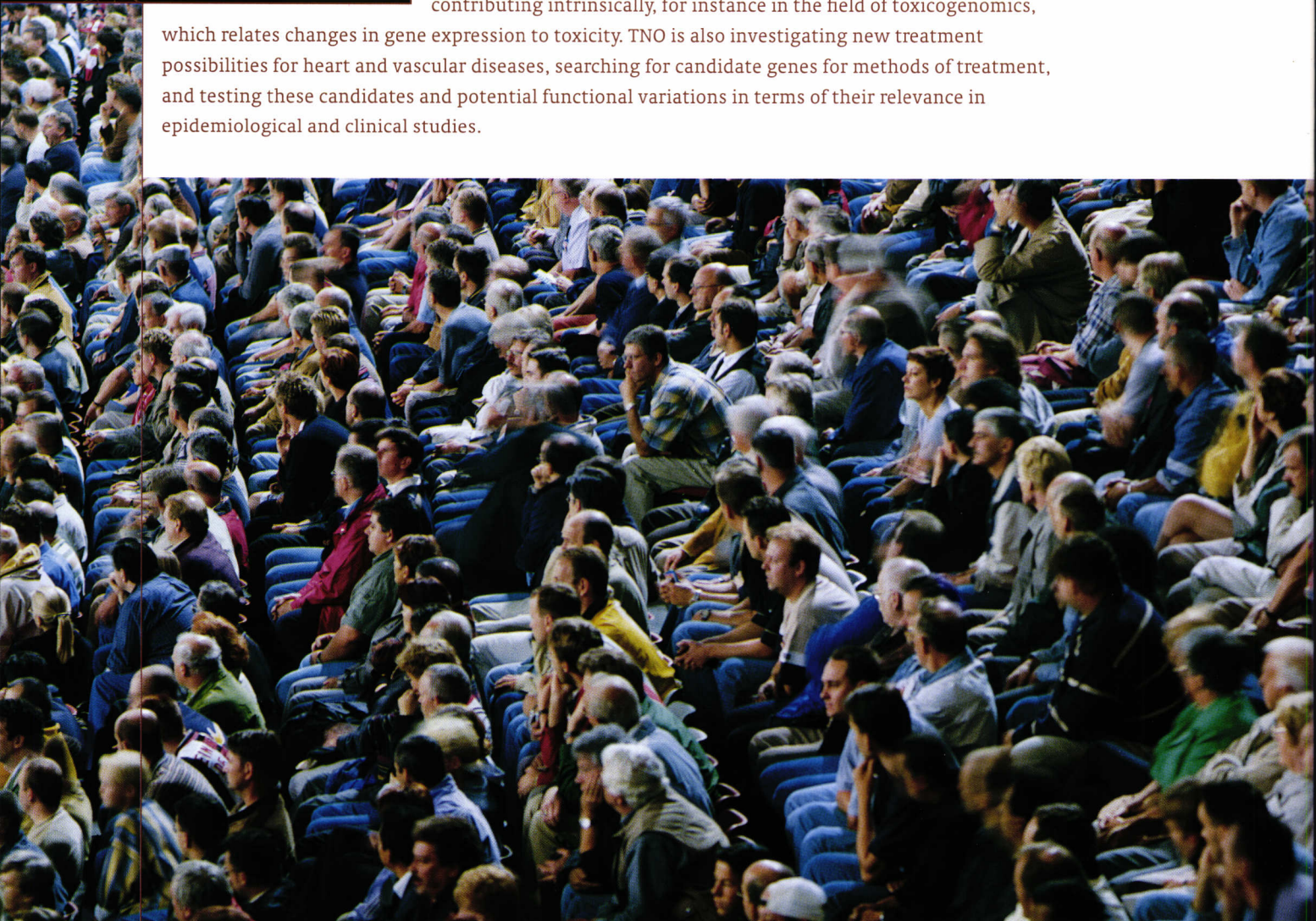
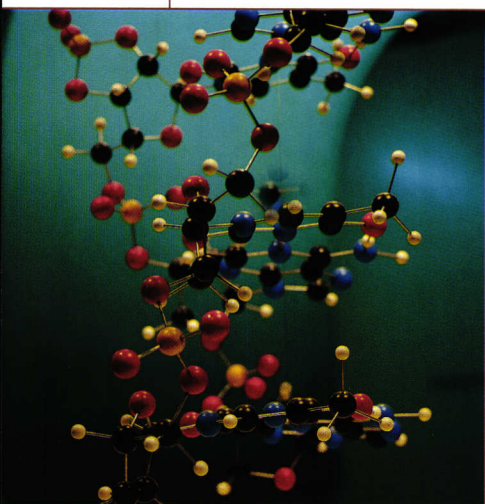
Human beings have around 30,000 genes composed of billions of DNA letters. They determine in part how we look and how we function. Thanks to genome identification, researchers are now starting to understand how cellular processes work. And before long old age and illness will relinquish their secrets too – assuming that researchers get a handle on the enormous quantity of data being generated by the new DNA chip technology. In April 2000 TNO advised the Minister of Economic

Affairs to boost genomics research through an innovation-g geared research programme. Over the next eight years some fourteen to eighteen million euros will need to be devoted to a number of spearheads of the research. But before the money is spent, we first need to know what is already happening in the field. Where is the need for knowledge greatest? Should we in the Netherlands reinforce our strengths or strengthen our weaknesses?

In response to these well-founded investment questions, TNO suggested answers. Following discussions with representatives from industry and the research world, three very promising genomics themes emerged: old-age illnesses, food functionality and metabolic processes.

The Ministry heeded the advice and in October the programme got up and running. TNO is acting not only in an advisory capacity but also contributing intrinsically, for instance in the field of toxicogenomics,

which relates changes in gene expression to toxicity. TNO is also investigating new treatment possibilities for heart and vascular diseases, searching for candidate genes for methods of treatment, and testing these candidates and potential functional variations in terms of their relevance in epidemiological and clinical studies.

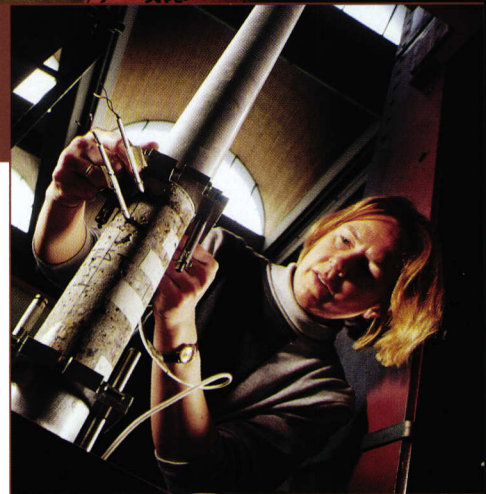




## The Enschede fireworks disaster: A story of concrete and steel

After the fireworks disaster in Enschede, the Netherlands was faced with the question of how such a thing could happen. The Netherlands Forensic Institute and the Public Prosecutions Department therefore employed the services of the explosives experts at TNO. To support the criminal investigation, the cause and course of the events as well as an explanation for the exceptionally severe effects of the explosions had to be scientifically substantiated.

Immediately after the disaster, the experts analysed the visible effects of the damage in the district. Craters marked the exact locations of explosions. Damage to the undersides of steel and concrete, as shown by fractures and cracks, revealed the violence and location of the first and second explosions. Damage to the surroundings displayed various contours ranging from the extremely serious damage to houses and factories near the explosions to window breakage in the outermost edge of the disaster area. Together with local damage, these contours provide information about the force and type of explosion involved. Although technical reasons have prevented the exact cause of the disaster from being determined, the experts have been able to reconstruct the sequence of events. Where it originated, how it expanded and where the most violent explosion took place could be reliably determined by a process of elimination.

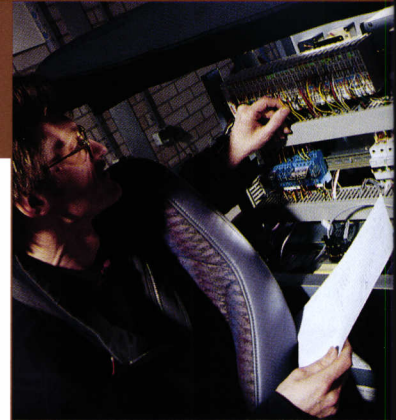




## RoboJeep: Driver not included

The vision of a robot that takes over dangerous, heavy or monotonous work from people is an old one. But progress in sensor technology, signal processing, information and communication technology, simulation and other disciplines has made it more real than ever before. TNO's RoboJeep is a shining example.

Built-in equipment such as sensors, stereo-cameras, a laser scanner and a GPS system have made the vehicle autonomous, able to carry out missions in rough territory on the basis of its own intelligence and ability to calculate. An important system for the Jeep is the Smart Teleoperation Workstation adapted from TNO's Moonrover. It uses simulation technology to determine for itself the correct route through any type of terrain. On the basis of the information it receives, it can control the actuators for the gearbox, the steering wheel and the accelerator and brake pedals. The possibilities that further developments to the vehicle will open up are countless – detecting and clearing mines, during military and police actions in urban areas, or undertaking reconnaissance missions and rescue operations. The challenge lies in extending the types of terrain in which RoboJeep can operate. The knowledge gained during this process is of great value for other unmanned applications on land, at sea and in the air.



## An increasingly clearer picture: Mapping soil, air and water pollutants

To what extent is the Netherlands achieving its intended reductions in regard to emissions? This is a question that is especially germane to greenhouse gases. The annual Emission and Waste Report submitted to the Superintendent of Public Health for Environmental Protection provides the answer. This answer is based on information stored in the central database of the Pollutant Emission Register

at the National Institute for Public Health and Environment (RIVM). It contains the emission figures for a hundred 'key' substances and is based on estimates of emissions from agriculture, industry, traffic and transport, and many other sectors. Because the data entered into this database form the guideline for policy, it is very crucial for this data to be as scientifically substantiated as possible. However, given the broad scope of the issue and the many parties involved, the submitted data may be susceptible to margins of error.

Based on its long-term relationship with this client, TNO is guiding the reporting process – a process whereby continuous improvement in the accuracy of this detailed information is a key consideration. One recommendation provided by TNO, for example, was to base the system on modern ICT and to check the submitted data by means of expert

modules. Reporting parties should also be given the opportunity to communicate interactively over the Internet. This can promote an exchange of information that will provide policy with an increasingly stronger foundation.





## Deep Subsurface in three dimensions: **Finding a home for carbon dioxide**



In our densely populated country, the pressure on space is enormous, and the call to make use of the subsurface for all manner of things is increasing. Not only for gas and geothermal storage but also for CO<sub>2</sub> storage in the deep subsurface. It is an option that would reduce undesirable emissions into the air we breathe.

TNO's expertise in this field is second to none, having been involved in monitoring one of the world's first large-scale carbon dioxide storage projects in an aquifer in the Norwegian Sleipner gas field. The main tasks of the TNO experts were to interpret seismic data as well as model and predict the position and concentration of CO<sub>2</sub>. The outcome was a 'visible' image of the injected carbon dioxide, which facilitates the monitoring of the injection of carbon dioxide and any migration that may occur through the subsurface. Being able to precisely visualise the deep subsurface is an

indispensable tool in weighing up the possibilities of utilising the deep subsurface, like carbon dioxide storage beneath the Netherlands. The new three-dimensional digital atlas, which is equipped to do this, is available from mid 2000 on the TNO website. It will allow researchers and other users to see a spatial image of the geological structures beneath the Netherlands. A user can select which part of the Dutch subsurface he or she wishes to see and on what scale the image is represented.



## Transmural care: Not necessarily better

The healthcare sector is searching for ways to offer care as efficiently as possible. It is commonly felt that there is more cooperation and coordination necessary among general practitioners, the hospital and, for example, the nursing home. This is the objective of more than five hundred projects and programmes related to transmural care in the Netherlands. Even so, after ten years of implementing them, scarcely anything was known about their effectiveness. But when ZorgOnderzoek (Health Research) Nederland charged TNO with finding out, the situation changed.

TNO's investigation was focused on three commonly occurring disorders: diabetes mellitus, total hip replacement and cerebrovascular disorders (CVD). The unexpected conclusion was that transmural care was not necessarily better than traditional care. Among the diabetes patients receiving transmural care, a higher percentage was better regulated. Among the CVD patients, there was no difference in the duration of nursing care required. And the group having received new hips was actually worse off after six months in the transmural situation. Too much care had actually led to poorer functioning. These research findings are now being used to modify this combination of less effective but more expensive care. The use of human effort and resources spent on follow-up care focuses more explicitly on getting patients to function independently as soon as possible. The researchers are supporting this policy, and their expertise makes them ideal advisors.





## Evaluating Spatial Planning: **A policy disrupted by the economy**

How did the twelve years of spatial planning policy affect the Netherlands' competitive strength? How have cities and rural areas developed? This was the question submitted to TNO by the Parliamentary Task Force for the Fifth Policy Document on Spatial Planning.

What is now clear is that the lean years during which the policy emerged had had an excessive impact. The economic dynamism that followed completely absorbed this spatial planning policy. A good example of this was the dire need for spatial concepts applicable to transport hubs and main ports. Although cities benefited from this economic improvement and from the policy, certain areas that were actually unable to support additional development were developed anyway. The document's restrictive policy – the preservation of a sharp dividing line between urban and rural areas – failed. Residential areas developed according to this policy failed to lead to less mobility. In rural areas, the plans for reinforcing nature, agriculture and recreation had probably been too weak. The recommendations submitted by the Parliamentary Task Force followed this TNO analysis. The new spatial planning policy will have to focus more on development. This will require an implementation strategy including national investment and effective project procedures. The resources for implementing this policy, as well as employing an independent spatial planning agency, are sorely needed. Moreover, spatial planning needs to play a pivotal role in national projects.







Is it a bike? Is it a car?  
**No, it's MITKA!**



It looks pretty sleek, it's a three-wheeler, it's got an electromotor and it keeps you dry. Not only that, it's coupled to a whole range of services like battery-charging and repair. In short, that's what the car-driving employees of Nike in Europe see as the ideal alternative for driving to and from work, according to recent interactive research. Practical research with existing vehicles has also helped generate a driver wish list.

In fact, it is these wishes that form the starting point for a vehicle being developed jointly by Gazelle, Nike, Stork and TNO in the Kiem-EET programme. MITKA (the acronym for the mobility concept for short-distance individual transport) is the catchy name that has been assigned to the end product. It is very nimble and even has a range of roofs for all kinds of weather. You can pedal if you want, but there's

always plenty of supplementary power in the electromotor. And for this vehicle, traffic jams are a thing of the past. But MITKA is not only fun, it's also environmentally friendly. With more than 85% of the driving in the Netherlands being done on environmentally unfriendly stretches of road of less than twenty kilometres, this vehicle is a 'clean' alternative. The concept already has a lot of takers, but they will have to be a little patient. The prototype, though, is already here.



## The Royal Netherlands Army: A well-oiled logistics system



'Logistics' is a military invention. Nevertheless, TNO's assignment from the Royal Netherlands Army was to compare its logistics with that of those superstars of civil logistics like courier companies and supermarkets. The suspicion was that the Army's logistics system was not performing as well as it should in order to handle such current military tasks as peace missions. Might the Army's logistics be more effective and more flexible? TNO confirmed these suspicions and also came up with a proposal to redesign the system.

The basic principle involved combining the separate flows for rations, spare parts and medical goods into a single distribution channel. A second major change is located at the end of the distribution chain: units no longer need to pick their things up but order them as clients and have them delivered. This requires an order-oriented system with a reliable communication structure and quick information processing. After all, units that move to another location still have to have their goods delivered to the right place! As far as the material is concerned, the introduction of a multifunctional loading system is making a considerable improvement in flexibility, allowing trucks to transport various loads that, like containers, are transhipped as entire units. The logistics management follows the new strategy: central management combined with decentralised control. The organisational structure is changing as well, with the Army creating its own logistics service provider.

QMIC®:

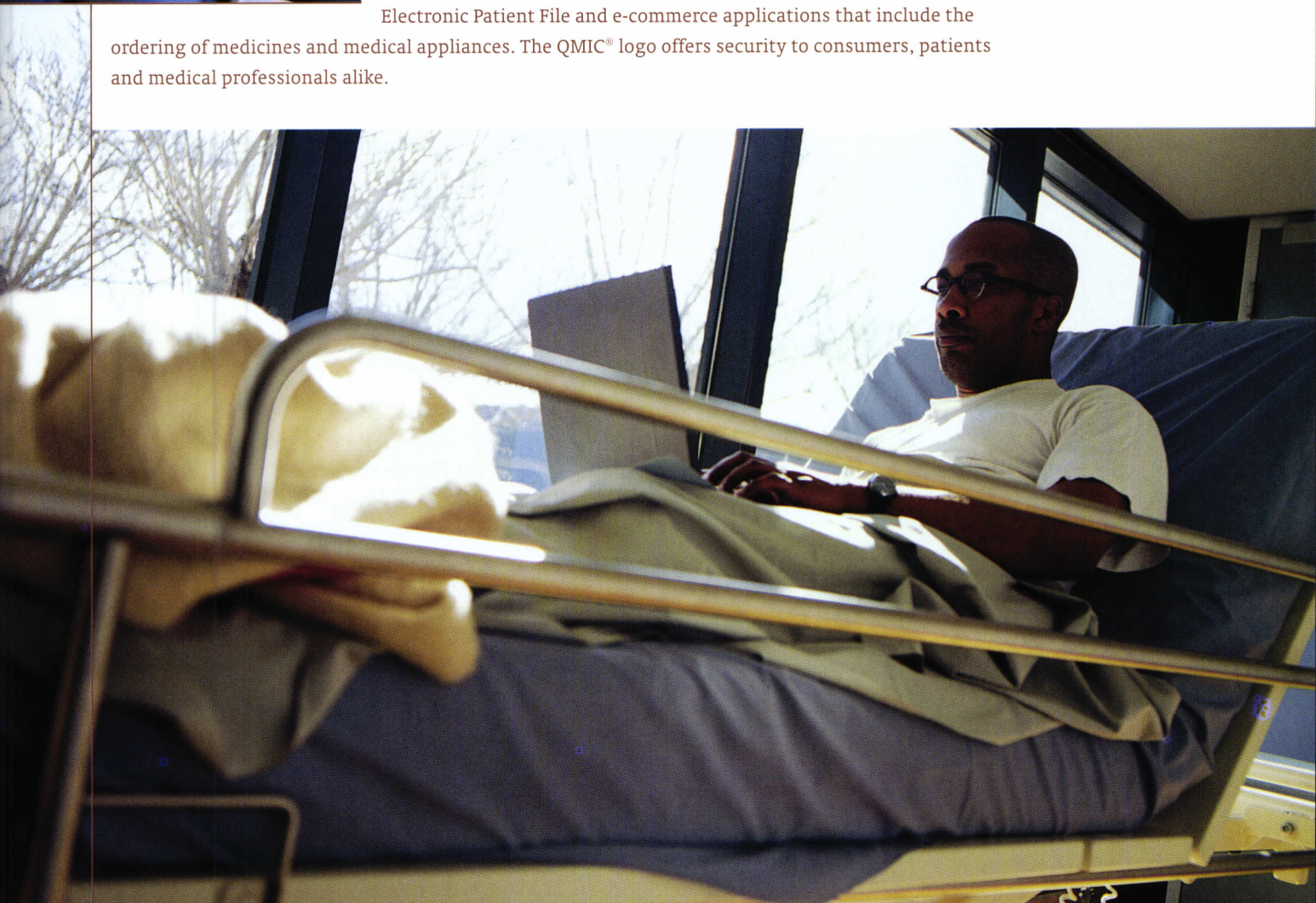
## Reliable medical information on the Web

The Internet plays an important part in the medical world. Patients exchange information and experiences over the net, and physicians and researchers use the web for their research purposes, for consulting with colleagues and for maintaining patient contacts. Almost every health care organisation has its own website. But is all this information accurate and reliable? Are organisations dealing

discreetly with confidential information? For a sensitive subject such as health, it would be desirable to have an official assessment and monitoring of the quality of these sites. Now, organisations that want to ensure the quality of their medical Internet sites and services can use the QMIC® Portal System developed by TNO. This 'Quality for Medical Information & Communication' label on a site means that the organisation behind the website has met all the criteria applying to the quality and confidentiality of the content on the site. The label guarantees that an independent agency within the organisation – a 'notified body' – assesses every webpage.

TNO has years of experience in quality management systems and in monitoring and guaranteeing this process of self-certification as an external consultant. The QMIC® system is capable not only of monitoring the quality of medical information but can also guarantee the reliability of communication and transaction services such as the Electronic Patient File and e-commerce applications that include the

ordering of medicines and medical appliances. The QMIC® logo offers security to consumers, patients and medical professionals alike.





Safe food:

## Controlling animal production chains



Food is a primary necessity of life. As such, it must be safe. Gaining insight into the dangers surrounding the origin and production of foodstuffs, and correctly estimating the levels of risk associated with these are the first steps in making food safe. The essential next steps are to impose adequate measures and regularly test them so as to control and safeguard the risks. TNO carries out assignments for commodity boards, business and governments to develop and improve systems such as these, drawing up risk inventories for various flows of raw materials such as moisture-rich fodder and fats for deep-frying. TNO has collaborated on work for the GMP+ regulation for the animal feed sector, based on HACCP standards, and is also active further up the animal production chain.

In the Chaperonnes programme – initiated by the Dutch Ministry of Agriculture – TNO is developing a new monitoring and surveillance system based on risk analyses. This aims to optimise the efficiency, effectiveness and transparency of government control over all meat and dairy production. To be able to guarantee safety, the systems in the chains must dovetail with each other. Tracking & Tracing systems are vital to this. TNO is working on the improvement of these systems, whose job it is to vouch for the origin of raw materials. Together with commodity boards, TNO is developing an ‘Early Warning & Response’ system in which the chain receives signals promptly in the event of potential calamities. This facilitates rapid assessment and the imposition of measures in time. All these activities help ensure that the safety of food for humans and animals reaches new levels, step by step.

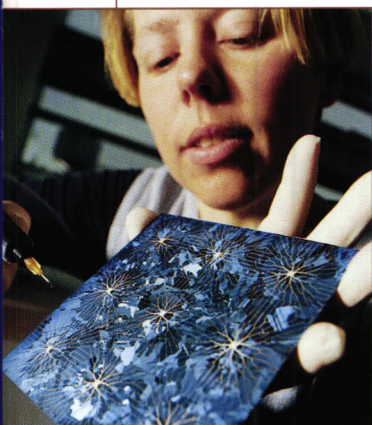
## Photovoltaic solar energy: Radiant future

The shortest route from sunlight to electricity is through photovoltaic solar energy (PV). TNO is one of the innovators that are constantly pushing back the frontiers of this technology. The Sunovation

project, in which Shell is a key partner, is one example of this. Current production of PV modules with solar cells of multicrystalline silicon is small scale and largely manually intensive. Sunovation is aiming to halve the cost of producing the cells, binding them together and manufacturing the full module within a few years.

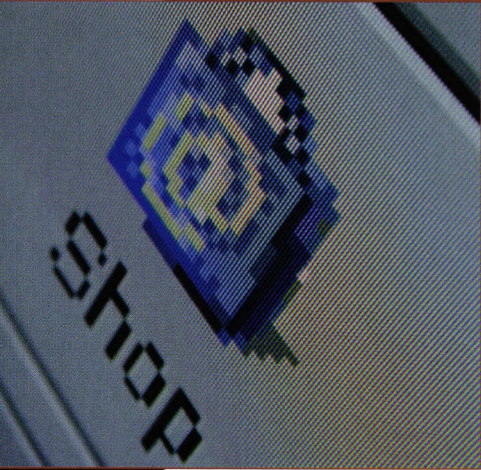
This can be done, for example, by finding an alternative to the very energy-intensive and time-consuming module 'baking'. The Helianthos joint venture, which includes Akzo Nobel and TNO, is working on a new generation of solar cells – flexible PV polymer foil with solar cells constructed from a thin layer of amorphous silicon. A cheap semi-continuous production process will more than adequately compensate for the relatively low yield from the PV foil. At the basis is a new production method that applies metal foil as a

temporary substrate and makes it possible to apply the layers of the solar cell at relatively high deposition temperatures. After the metal foil is removed, the polymer protects the solar cell on both sides at a relatively low melting point. The cost of production is not the only plus of this technology. Equally important is the ease with which the PV foil can laminate building elements like roofs and gables.



Trade Agents:

## Your personal web negotiators



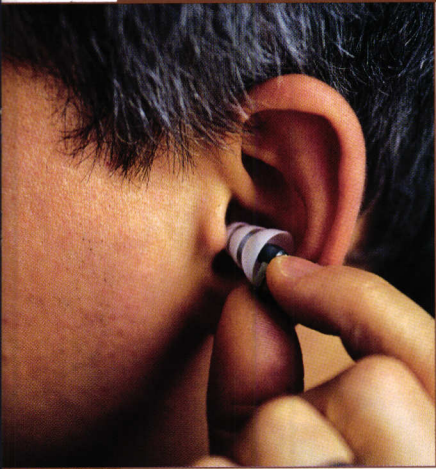
The Internet's expanding ceaselessly.... so how are you as a user supposed to quickly find the products and services that are tuned to your individual tastes and requirements? By using a 'trading software agent', or a trade agent for short! This agent is, in fact, a software module that can independently observe his Internet environment, respond to it and use his intelligence to learn from what he experiences along the way. So a user that has such an agent at his disposal does not have to drop in on various sites. He just has to instruct the agent to do that. Indeed, the agent does more than just search and select, he can even negotiate prices.

This will soon be the reality if the Centre for Mathematics and Informatics (CWI) and TNO have their way. Both institutes are undertaking a development programme for the Telematics Institute for whom the ING banking group and KPN Research have commissioned research into the development of applications. For KPN Research this is an electronic shopping centre in which the shopping centre itself, the shops and the customers each have agents to foster the interests of the respective party – in terms of prices, conditions and information exchange. ING is more concerned with the role of financial information broker whereby the user pays according to the current value of the information. TNO is also looking into the possibility to standardise the information and make it secure.



Noisy helicopters:

## Talking comfortably in the Chinook



In 1996 the Netherlands Ministry of Defence bought American Chinook helicopters. However, the level of noise inside these helicopters proved detrimental to the crew's working conditions and had a tangible negative effect on the audibility of intercom communication between crew members. Thorough tests revealed that the protection chosen to deal with the noise was insufficient for this particular type of sound. Would it be possible to achieve a reduction in the level of noise on the ear and be able to communicate clearly at the same time?

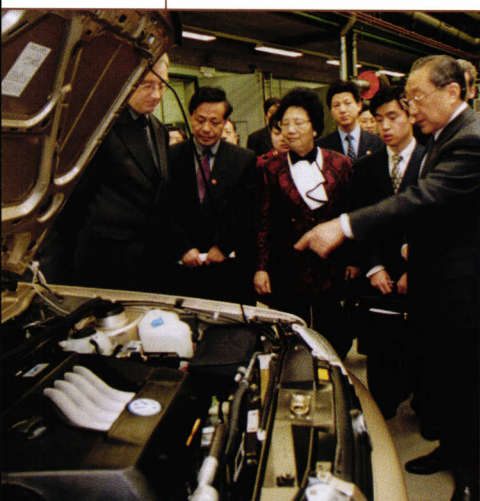
TNO researchers set to work. It quickly appeared that a different helmet, however good, would not offer sufficient comfort, though extra earplugs temporarily offer a perfect solution. But this option does mean that the intercom volume must be significantly turned up. So wouldn't it be great to have earplugs with built-in headphones for the intercom? In itself, this appeared to be an attractive solution, its only disadvantage being the need for inconvenient wires between helmet and earplugs. And so, TNO devised a wireless solution that conforms to the exceptionally stringent military requirements for radio signals. This 'wireless communications earplug' works without batteries. It uses energy from the transmitting equipment – without requiring a stronger transmitter. Advanced plans for series production are on the table, and crews will soon be able to talk comfortably.



## LPG projects: Blue skies above China

This past twenty years has seen Chinese economic growth breaking all records. Unfortunately this growth has been paralleled by an increase in emissions of exhaust gases. More and more Chinese are recognising that this is a problem, according to TNO staff who undertook an orientation visit in 1997. The contacts made then led to a pilot project in the following year for city buses in Beijing, in which a Dutch LPG consortium gave the Chinese capital the opportunity, on a small scale, to become acquainted with this alternative fuel. In a subsequent project, specially developed hypermodern LPG installations were built into eighty taxis, comprised of four different makes of car (Citroën ZX, Daihatsu Charade and VW's Jetta and Santana). These taxis were able to fill up at an LPG filling station in Beijing; another two filling stations are due to be added. In addition to layout and coordination of these stations, safety was one of TNO's tasks in the project. Furthermore, TNO was able to guarantee via laboratory controls that the systems fulfilled very stringent emission requirements. In the future monitoring will be able to reveal that these requirements can be met in the long term.

The importance of the project was underlined by the request of Chinese vice-premier Li Lan Qing to visit TNO's emissions laboratory to get an update on the project's progress. The Dutch consortium will be attempting to win the favour of all the Chinese for the Dutch answer to alternative fuels at an annual trade fair in Beijing so that in time blue skies can once again be seen over the capital.



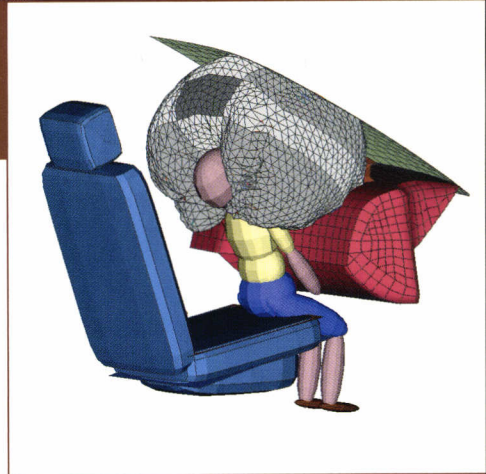


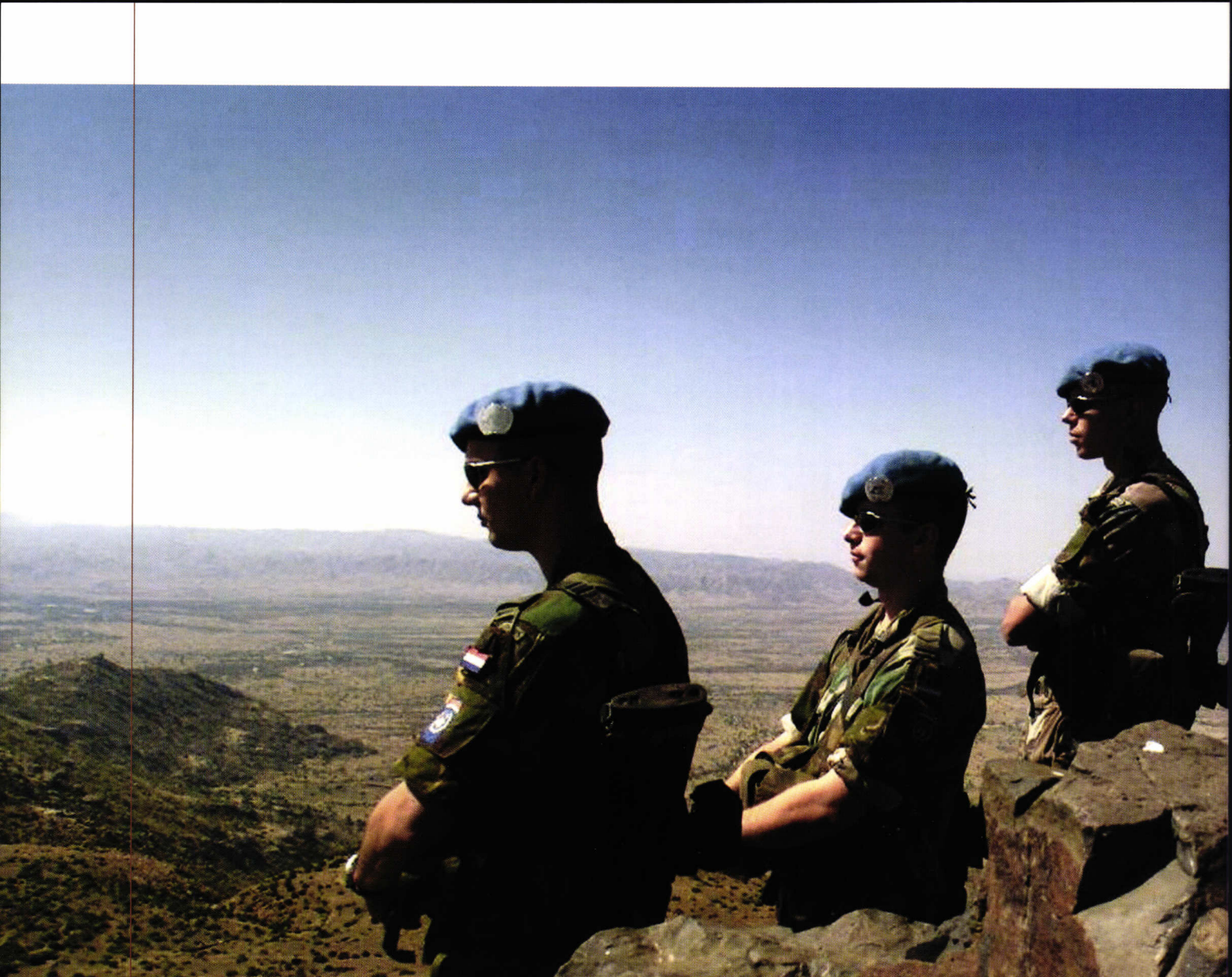


## MADYMO for safety: Faster testing for safer cars

Car seats and airbags may have already saved many lives but that fact doesn't stop the forty or so engineers at TRW Occupant Safety Systems using MADYMO in their efforts to improve these safety systems yet further. TNO is not just a supplier of software licences; a number of TNO staff are engaged full-time, working with the people at TRW, also advising on how to use MADYMO in the development of new airbags.

TRW is one of the large worldwide suppliers of car components. Its engineers use MADYMO to simulate the effects of frontal collisions, side impact and car tilting. Apart from having a comprehensively validated dummy, the model contains very accurately calculated components: a car seat, seat belts, instrument panel, dashboard and a steering column with airbag. The engineers are able to adjust the geometry of this to suit the car design, the occupants and the safety measures. In consecutive tests they modify the parameters until an optimum solution emerges. It is precisely the possibility to complete test runs at speed that is a strong feature of MADYMO. How, how fast and using how much air does an airbag have to unfold in order to provide the greatest possible protection? By using numerical simulation programs TRW can reduce the number of physical tests over a three-year period by forty percent, a saving of millions of dollars. Even more importantly, however, this fast very focused development of new safety systems makes the road just that little bit safer.





## Putting Eritrea on the map: Helping the Peace Mission find it's way

At the end of 2000 Dutch military forces left for Ethiopia and Eritrea on a peace-keeping mission as part of the UN Mission (UNMEE). Without good mapping materials it is not possible to safely and effectively patrol the border area between these two countries. During the planning for the mission, the Operational Information Services department of the Royal Marines confirmed that the available maps were too crude, old and unreliable. Could TNO quickly provide an alternative to ordnance survey maps?



The answer to that was yes, by employing various commercial Earth observation satellites that work in visible light, radar and infrared, able to reveal details up to six metres. The satellite pictures of the Earth can then be worked up into maps while retaining the satellite image as background. This background includes all sorts of recognisable objects such as roads drawn in yellow, rivers in blue and conurbations in red. The maps with a scale of 1:50,000 also include vital altitude lines. They are delivered on both paper and in digital form. The 101 Military Information platoon in Ede was responsible for the bulk of the production work. At the request of the Military Geography department of the Royal Army the map pages were printed by the Dutch Topographical Service. In doing this, the military used knowledge and tools supplied by TNO and its collaborative partners such as the National Air and Space Laboratory and the firm ESRI. Within two months the project team had mapped almost 20,000 square kilometers.



## Work pressure: Can it be a little less?



Too much work, too little time – and not having any control over the situation: that's the cause of work pressure. Vague arrangements, insufficient collaboration, bad planning and poor use of resources all contribute. With the shortest and most intensive working week, pressure of work is no stranger to the Netherlands. TNO does a lot of research into this subject and carries out improvement tasks.

These aspects are combined in a project at the Martini Hospital in Groningen. The hospital had a high rate of staff absence through sickness and acknowledged the likelihood of work pressure contributing to this. TNO assessed the tasks comprising the work of the departments in the Centre for Internal Medicine. Measured against the TNO reference database of the Dutch population, could work pressure be considered an issue at the hospital? Indeed, the work pressure within some

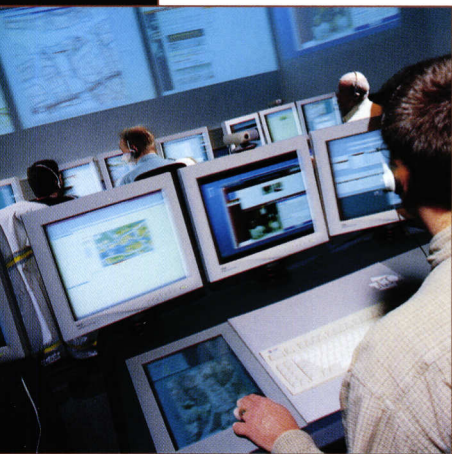
departments did appear high. To tackle this problem, researchers, hospital management and the departments involved undertook a course of action. At three meetings the parties delved into the underlying causes of the problems. What demands are placed on employees? Are they unreasonable? What are the solutions? By tackling these questions, an organisation learns to manage the pressure of work itself. TNO transferred the methodology to HR advisers who would manage the introduction of measures. Levels of enthusiasm within the Martini Hospital are high; after the Centre for Internal Medicine, the Centre for Neurosurgery/Orthopedics went to work. Other centres will follow.



GAMMA-EC:

## Focused preparation for disasters

Fortunately, disaster management is not a daily routine task – not even for the fire brigade, police and other emergency services. This means that preparing for calamities is usually a matter of enacting dry runs, normally involving just one emergency service. As a result, the co-ordination between emergency services in real situations is not practised enough. Precisely because of this, the aim of the European GAMMA-EC project is to foster interdisciplinary collaboration during disaster management. In addition to a multimedia self-study application, based on Internet/Intranet techniques, an interactive 'game' simulation has been developed for interdisciplinary team training.



One of the ways in which this kind of simulation supports those supervising the dry run is in the creation of the disaster scenario. Where the interactive simulation really proves its worth, however, is in actual interdisciplinary team training. The 'disaster' unfolds realistically. The actions and decisions taken by the players help determine how the scenario progresses. The training situation mimics the actual work situation of the team practising as closely as possible. For example, the emergency workers receive information about the course of the disaster via their normal communication channels. This enables emergency workers to train as realistically as possible essential skills such as coordination, communication and decision-making under time pressure and on the basis of limited and sometimes inadequate information.

KAPLA:

## Building demand-driven ventilation in houses

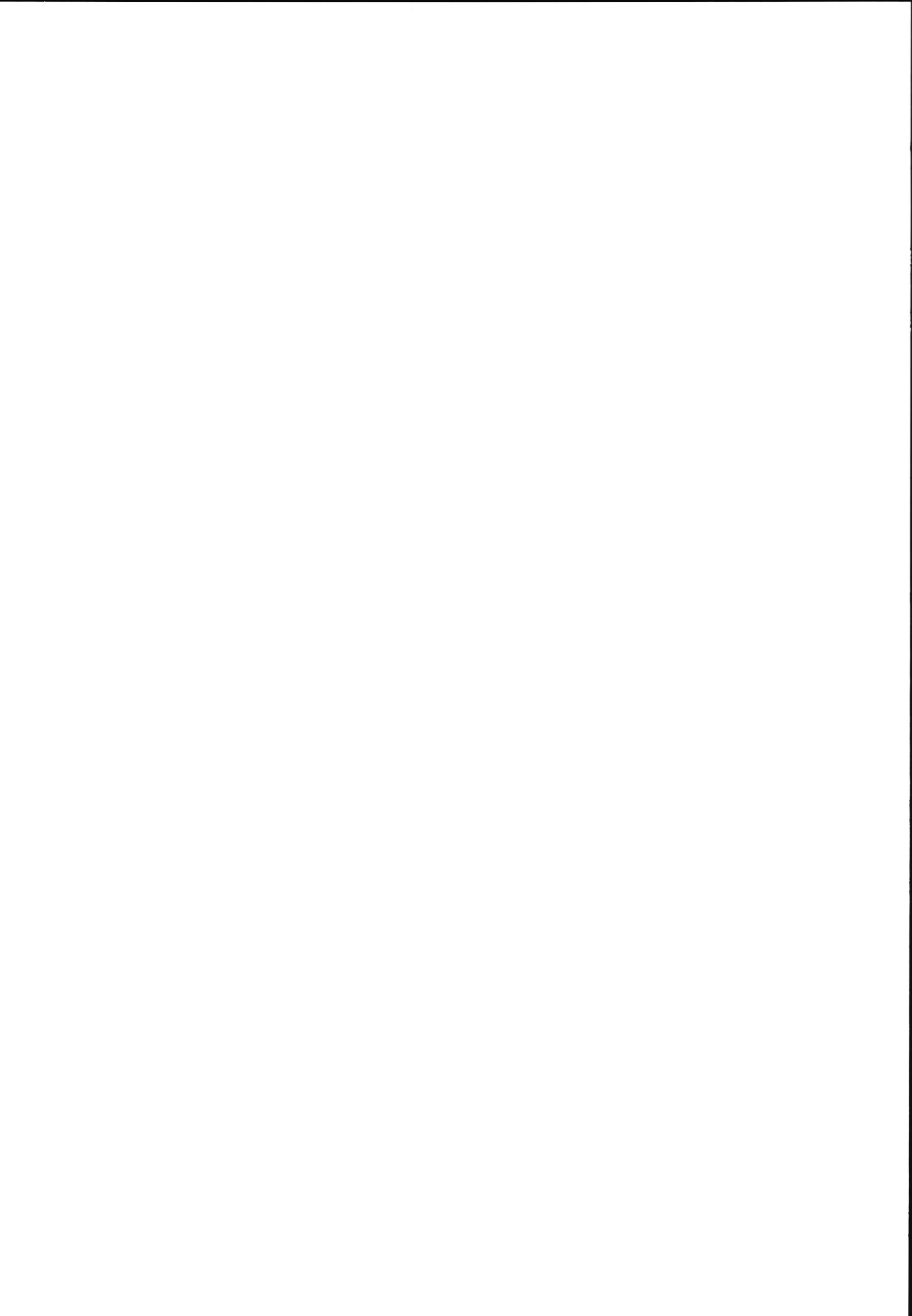
Plastering traditional door and window frames into a façade is skilled work. During the construction phase the frame is first placed and painted with undercoat. The glass is inserted later, often under poor working conditions. During construction frames are often damaged. The placement of ready-made elements, which goes by the Dutch acronym KAPLA, offers a wonderful alternative. This is certainly the conclusion of six projects in which TNO has collaborated with major players in the construction sector.



Simple temporary frames are positioned in the new construction. The permanent frames are painted and fitted with glass under comfortable working conditions at the joiner's. The ready-to-use frames arrive at the construction site to be fitted just before completion, so they have no time to get damaged. As KAPLA frames include details in their fitting that prevent contact between wood and stone, softwood frames are given a much longer life span. This makes the use of hardwood unnecessary. Pre-delivery placement offers an unexpected advantage; it makes it possible to build in demand-driven ventilation (KAPLA-VENT). Usually

the electronics this requires would not survive the construction phase. Sensors in the ventilator grating are linked to a computer in the meter cupboard, which adjusts the ventilation automatically. The KAPLA principle has been raised to the status of a demonstration project for Industrial, Flexible and Deconstructable (IFD) building and for demand-driven ventilation.





## TNO in figures

# Consolidated balance sheet as at 31 December 2000

after appropriation of result (in thousands of euros)

	31-12-2000	31-12-1999
<b>Fixed assets</b>		
Intangible fixed assets	189	81
Tangible fixed assets	237,135	212,151
Financial fixed assets	5,802	7,536
	<b>243,126</b>	<b>219,768</b>
<b>Current assets</b>		
Stocks and work in progress	20,498	24,563
Accounts receivable	102,637	97,279
Securities	56,035	52,321
Cash	- 33,104	- 30,998
	<b>146,066</b>	<b>143,165</b>
<b>Total</b>	<b>389,192</b>	<b>362,933</b>
<b>Financed as follows:</b>		
Equity:		
– General reserves	200,653	202,364
– Appropriated reserves	9,268	4,506
	<b>209,921</b>	<b>206,870</b>
<b>Investment funds equalisation account</b>	<b>7,930</b>	<b>8,760</b>
<b>Third party interests</b>	<b>- 20</b>	<b>34</b>
<b>Provisions</b>	<b>33,025</b>	<b>22,416</b>
<b>Long-term debts</b>	<b>4,826</b>	<b>2,855</b>
<b>Short-term debts</b>	<b>133,510</b>	<b>121,998</b>
<b>Total</b>	<b>389,192</b>	<b>362,933</b>



# Consolidated profit and loss account 2000

(in thousands of euros)

	2000	1999
Turnover	479,454	440,397
Other operating income	16,264	28,207
<b>Operating income</b>	<b>495,718</b>	<b>468,604</b>
Personnel costs *)	- 297,807	- 264,187
Direct project costs	- 69,972	- 69,800
Other operating costs	- 86,563	- 92,649
Depreciation intangible fixed assets	- 278	- 51
Depreciation tangible fixed assets	- 37,461	- 32,314
Contributions issued	- 495	- 535
<b>Operating costs</b>	<b>- 492,576</b>	<b>- 459,536</b>
<b>Operating result</b>	<b>3,142</b>	<b>9,068</b>
Income from financial fixed assets	57	1,463
Income from securities	6,670	- 4,164
Interest received	2,607	1,228
Interest paid	- 4,489	- 1,437
<b>Result from ordinary operations before taxation</b>	<b>7,987</b>	<b>6,158</b>
<b>Tax</b>	<b>- 744</b>	<b>- 305</b>
<b>Result from ordinary operations after taxation</b>	<b>7,243</b>	<b>5,853</b>
Third party interests	17	- 10
<b>Result</b>	<b>7,260</b>	<b>5,843</b>
<b>Appropriation of result:</b>		
<b>Result</b>	<b>7,260</b>	<b>5,843</b>
Addition to:		
– appropriated reserves for operating risk	- 2,493	- 2,237
– appropriated reserves for knowledge investments	- 2,269	- 2,269
<b>Result after movements in appropriated reserves</b>	<b>2,498</b>	<b>1,337</b>
Additions to general reserves	- 2,498	- 1,337
	–	–

\*) – including personnel profit sharing (2000: nil; 1999: € 1,914)

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