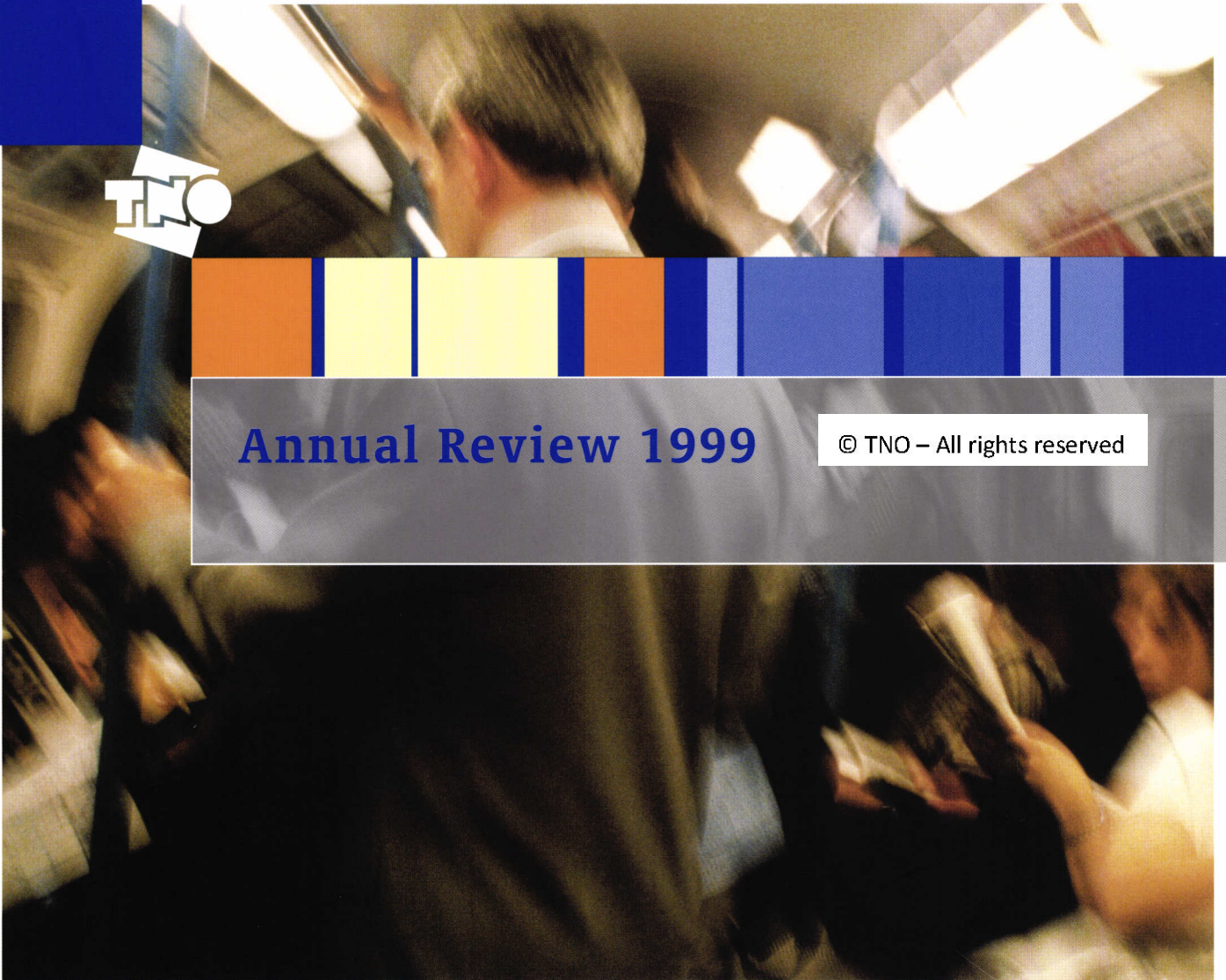




Annual Review 1999

© TNO – All rights reserved



TNO is a leading independent contract research company where more than 5,100 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 multi-disciplinary 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.

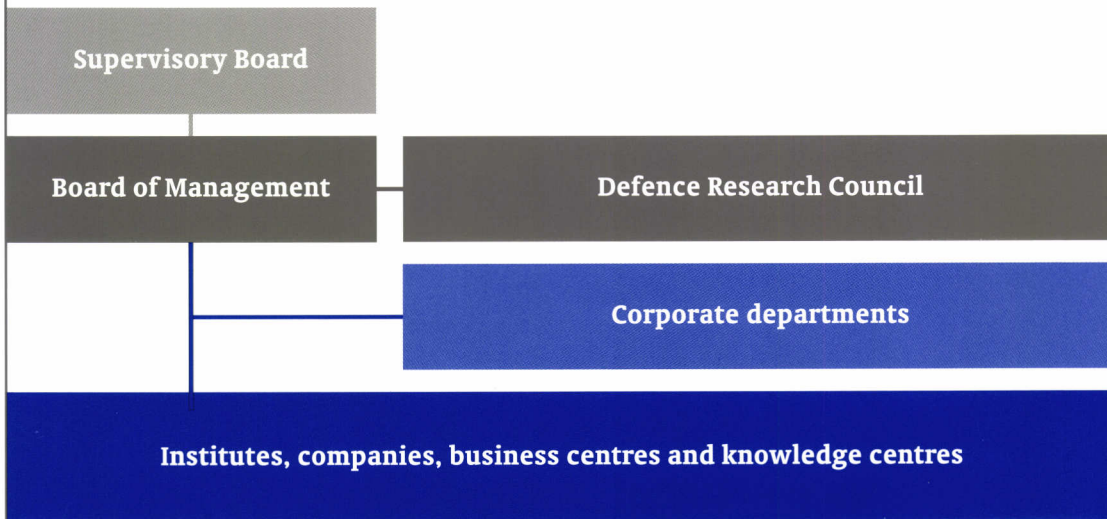
TNO's commitment to facilitating the interests of a broad range of businesses as well as organisations and governments is underlined by a strong focus on quality, creativity, accessibility and entrepreneurship.

Contents

2	Organisation structure
3	Key figures
4	Supervisory Board
4	Board of Management
4	Defence Research Council
5	TNO in 1999
6	Abridged report from the Board of Management
16	Senior Research Fellows
19	TNO in practice
49	TNO in figures
50	Consolidated balance sheet as at 31 December 1999
51	Consolidated profit and loss account 1999

TNO Annual Review 1999 is an abridged version of the Dutch 'TNO Jaarverslag 1999'.
In matters of interpretation the Dutch text will prevail.

Organisation structure



Key figures

in millions of euros (unless stated otherwise)

	1999	1998
Government funding turnover	144.5	144.4
Market turnover TNO	279.6	242.4
Turnover TNO	424.1	386.8
Turnover TNO participations	21.1	19.0
Consolidated market turnover	295.9	259.1
Consolidated turnover	440.4	403.5
Net turnover ¹⁾	370.6	334.2
Added value ²⁾	305.6	261.9
Result before personnel profit sharing	7.8	6.8
Personnel profit sharing	1.9	–
Result	5.9	6.8
Result as % of market turnover	2.0%	2.6%
Operating result TNO	9.1	- 0.6
Operating result institutes (incl. defence research institutes)	6.7	7.9
Result TNO institutes	7.5	9.8
Number of TNO employees (effective average)	4,518	4,073
Number of employees TNO participations (effective average)	182	140
Number of employees (effective average)	4,700	4,213
Net turnover per TNO employee in euros x 1000 (effective average)	78.9	79.3
Added value per TNO employee in euros x 1000 (effective average)	65.0	62.2
Personnel costs per TNO employee in euros x 1000 (effective average)	56.2	55.1
Personnel costs	264.2	232.2
Operating capital	21.2	52.7
Equity	206.9	202.7
Cash flow	56.7	38.5
Capital expenditure	75.8	53.4
Average term of work in progress and debtors in months (TNO institutes)	4.5	4.4
Current ratio	1.17	1.49
Solvency	0.57	0.57

1) – Net turnover = turnover - direct project costs

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

Management

TNO Supervisory Board

(composition as at 1 April 2000)

Prof. R.F.M. Lubbers, *chairman*
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
R.J. de Wijkerslooth de Weerdesteijn, M.Sc.
H.P.C. Wellen, LL.M., *secretary*
P.O. Box 6000
NL-2600 JA Delft
Phone +31 15 269 69 00
Fax +31 15 262 73 83
E-mail wellen@rvb.tno.nl

TNO Defence Research Council

(composition as at 1 April 2000)

E.I.L.D.G. Margherita, M.Sc., *chairman*
Cdre. D. van Dord, M.Sc., *vice-chairman*
R.Adm. J.W.P. Spaans
Maj.Gen. D. Starink
Maj.Gen. W.H. Zoomers, LL.M.
Cdre. J.M.W. Willems, M.A.
J. Bezemer, M.A.
Prof. K.F. Wakker
Prof.dr. L.F.W. de Klerk
L.J. Halvers, M.A.
Prof.dr. R. de Wijk
Captain (N) W. Nagtegaal
R.P. Perié, *secretary*
P.O. Box 6006
NL-2600 JA Delft
Phone +31 15 269 47 27
Fax +31 15 262 73 19
E-mail perie@do.tno.nl

TNO Board of Management

(composition as at 1 April 2000)

J.A. Dekker, M.Sc., *chairman*
F.Th. Gubbi, M.Sc., *vice-chairman*
Dr. P. Folstar
E.I.L.D.G. Margherita, M.Sc.
H.P.C. Wellen, LL.M., *secretary*
P.O. Box 6000
NL-2600 JA Delft
Phone +31 15 269 69 00
Fax +31 15 262 73 83
E-mail wellen@rvb.tno.nl

TNO in 1999

Abridged report from the TNO Board of Management



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

Introduction

The year under review saw the 'Agenda for TNO', the Strategic Plan for 1999-2002, get under way with most of the resolutions for 1999 having been implemented or initiated. Most of the strategic objectives set were realised in quantitative terms in the past year. Consolidated turnover rose by 9 percent from € 403 million in 1998 to € 440 million, and a good 17 percent of this was for foreign clients. The result before profit sharing by personnel – which was introduced in 1999 – increased to € 7.8 million, a rise of almost € 1 million on 1998.

This predominantly favourable development is not unrelated to the thriving Dutch economy. The markets in which TNO is involved are also experiencing a surge, with both the public and private sectors perceiving a strong need for applied research. The 'Agenda for TNO' takes account of a steady increase in the outsourcing of R&D by companies. This view has certainly been confirmed. Government demand grew largely for research contributions to deal with problems in society.

Strategy

Each organisation needs to know where it is heading, and the 'Agenda for TNO' forms the guiding principle for our direction in the coming years. Furthermore, this Strategic Plan lays the basis for agreements with the Dutch government and other key relations, setting out, as it does, fourteen core areas that together form an excellent link between the powerful knowledge position of TNO and a substantial or growing social need.

Society will be faced by large and complex challenges in the years ahead. TNO believes it has a responsibility to provide a growing contribution to solving the problems in areas that relate to the expertise and

knowledge position of our company. Accordingly, the strategy aims at a marked increase in TNO's impact on the economy and society, and a rising turnover and return. The targets set for 1999 were, by and large, achieved.

Development of turnover

The turnover of the TNO organisation in 1999 was € 424 million; that for TNO's subsidiary – TNO Management B.V. (TMB) – was € 21 million.

The consolidated turnover of € 440 million represents a rise of 9 percent on the figure for 1998. Government funding contributed € 144 million to this figure while market turnover was good for € 296 million. *Figure 1* illustrates the development of turnover, split into market turnover and government funding. There was a 17 percent rise in domestic turnover, to € 219 million, with governments contributing € 54 million to this amount. Foreign companies and international organisations accounted for € 77 million of the total. The result of € 7.8 million on total turnover, which is slightly up on the 1998 profit figure of € 6.8 million, is appropriated to profit sharing by personnel

figure 1 – TNO's turnover

total 1999 € 424 million (TNO excl. TMB) – in percentages



■ market turnover excl. government funding
■ government funding



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

Dr P. Folstar

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

(€ 1.9 million), investments in new knowledge (€ 2.3 million) and the newly formed appropriated reserves for operating risks (€ 2.2 million). The remainder is added to the general reserves.

The operating result shifted from a negative of € 0.6 million to a positive of € 9.1 million. *Figure 2* summarises the market turnover in domestic (government and business) and foreign terms.

Internationalisation

In 1999 foreign turnover was € 72 million (TNO, excluding TNO Management B.V.), equivalent to 26 percent of the total market turnover of TNO (see *figure 3*). Foreign clients in Europe accounted for 51 percent of this figure while a good quarter of the turnover was derived from assignments for international organisations. Outside Europe, North America and Asia were major sales markets.

Many of TNO's clients are companies on the international stage. TNO's internationalisation policy is focused first of all on selling knowledge internationally

and then setting up sales support offices in those key external markets. For its core area 'Information and communications technology' (ICT), TNO set up an 'outpost' in Silicon Valley in collaboration with Twinning. The people stationed there are focusing on gathering knowledge as well as building relationships and on providing specific, quick innovations in products and services. Another key part of their activities is 'roadmapping' for new services in the Internet economy.

The ultimate goal of the internationalisation policy for TNO is to conduct research in other countries, not a goal TNO has to achieve all by itself: it is just as likely to set up joint ventures with international partners. In the year under review TNO and the Institut für Neue Materialien (INM) set up the European Centre for Product Innovation and Coatings (EPC) in Saarbrücken (Germany) to support our work in the 'New materials' core area. The EPC will further implement the results of joint INM and TNO technology. In 1999 the two institutes combined a major portion of their strategic knowledge bases in the TNO-TUE Centre for Materials Technology Centre in Eindhoven.

Furthermore, as for the ICT core area, TNO joined the

figure 2 – Market turnover

total 1999 € 279 million (TNO excl. TMB) – in percentages



- business
- foreign
- government

figure 3 – Foreign turnover

total 1999 € 72 million (TNO excl. TMB) – in percentages



- EU countries
- International organisations
- North America
- Asia
- Other European countries
- Other countries

UMTS Partnership for Development. German, Dutch and Swiss partners are working on development and advice in the area of third generation mobile on-line services.

A noteworthy development in the 'Nutrition and food' core area was TNO's acquisition of BIBRA Ltd. in the United Kingdom, which constitutes TNO's first international takeover. Not only is linking BIBRA with TNO an investment to deepen our involvement in food and toxicological research, it is an investment to broaden our area of activities. The collaboration of the information and clinical groups of TNO Bibra International Ltd. gives us the opportunity to gain a better position in the English market.

Personnel

TNO staffing, including the participations of TNO Management B.V., increased from about 4,800 to more than 5,100. The inflow and outflow of personnel was in line with projections; 733 new colleagues joined us while 414 employees left. On the list of 'attractive employers' TNO rose from a ranking of 98th to 17th place. Our position between universities and the private sector contributed to this rise along with our good employment terms and conditions.

Professor Pauline Verloove and dr Wim Bles were appointed Senior Research Fellows in 1999. Professor Verloove received this title due to her work in the area of preventive child healthcare and Dr Bles was rewarded for his efforts in the area of balance and orientation (see pages 16 and 17).

Market developments

Economic trends are positive, both in the Netherlands and in the surrounding markets that are significant for TNO. One of the reasons why TNO has been able to profit from this economic growth can be attributed to the active position it adopts in regard to its customers in these markets.

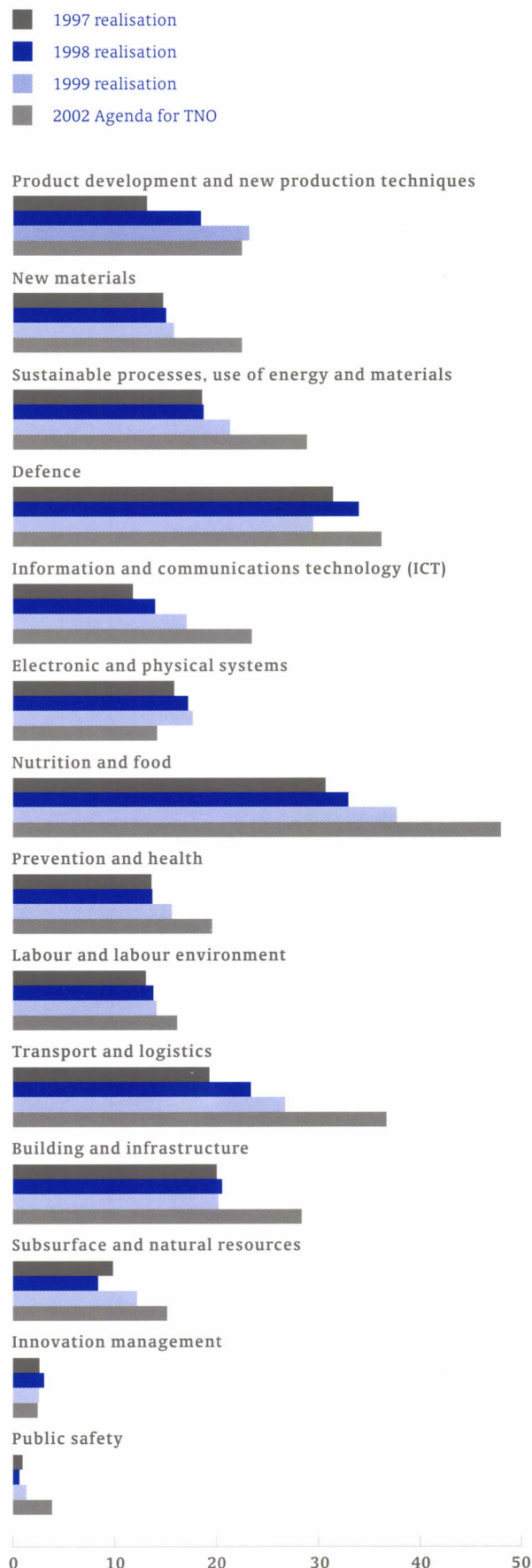
Figure 4 illustrates trends in market turnover for TNO's core areas. For each area a number of interesting developments occurring during 1999 are described below.

Product development and new production techniques

Market turnover within 'Product development and new production techniques' rose by 26 percent on 1998.

The strategic alliance with ASML concerning the development of new wafer scanners (chip production equipment) has been expanded. Increasingly more interfaces are being found with the focal activity of this

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



industrial partner. One of these is that TNO is working very closely with ASML on developing the next generation of wafer scanners.

'Medical Technology' and 'Portables and Wearables' are major targets for this core area. Within these areas industry has been provided with the first projects and products.

Product development and new production techniques
– millions of euros



A new partnership with PricewaterhouseCoopers is involved in supplying companies in the Dutch province of Flevoland with advice about product and production development. Yet another objective is to collaborate in establishing a large number of development projects. Together with Gallet CGF in France and Dräger in Germany, for example, researchers are working on an integrated fire brigade protection system that comprises a helmet, clothing, masks, breathing equipment and the requisite communication devices.

TNO is expanding the Rapid Prototyping Technologies it has developed itself using Rapid Tooling and Rapid Manufacturing. In the year under review, for example, a great deal of research was devoted to High Speed Milling, a type of Rapid Tooling. The results of this research were well received by industry.

Kathalys, a knowledge centre for sustainable product innovation, together with the Delft University of Technology and ATAG, worked on completing the conceptual phase of an extensive project for developing various kinds of kitchen equipment. Several new projects with leading industrial partners are currently in the preparation phase, like the development of 'the office of the future'.

New materials

Market turnover within the 'New Materials' core area rose by 5 percent on 1998.

New materials
– millions of euro



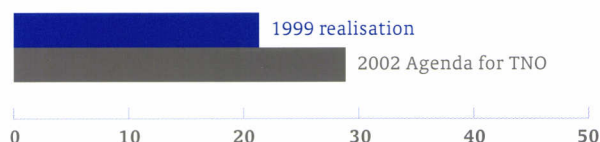
Within the new materials market, development has been particularly impressive for various projects over

the past year. A research group was quickly assembled, for instance, in the field of semi-conducting plastics. Together with the Dutch Polymer Institute and the Eindhoven University of Technology, this group is devoting its efforts to the use of fluorescent plastic surfaces and plastic electronics in such applications as displays, logic circuits and solar cells. In these projects, the researchers are collaborating with several leading European companies. Another development has been the use of nano clay additives in plastics to produce specialised polymers ('planomers') which was demonstrated successfully in their application in pressure moulds for ceramic products. The result is a threefold extension of the life span of these moulds.

Detecting moisture at a distance – telesensing – is an invention with commercial potential, which has been made possible by the development of a new material. A new Dutch company is going to join together with TNO in exploring the possibilities this offers.

Sustainable processes, use of energy and materials
Within this core area market turnover rose by about 14 percent during 1999, thereby strengthening TNO's position as a supplier of solutions for environmental and energy-related issues.

Sustainable processes, use of energy and materials
– millions of euros



With existing coolants affecting the ozone layer, TNO has been exerting efforts to discover new refrigeration and freezing equipment that uses air itself as a coolant. This AIR CYCLE technology also appears to work well in the air conditioning systems used in buildings. Another milestone was the invention of a new method, known as MEMSTILL, for the desalinisation of seawater, a process that consumes less energy and is cheaper than reverse osmosis. Furthermore, a computer program known as ODESSY that has been created to help in selecting energy-saving alternatives for industrial applications has been successfully employed by various industries.

In the fine chemicals field, a study was launched into miniaturising processes and making them more flexible. The objective is to find concrete solutions and methods to apply to innovative process concepts. Efforts also continued towards developing sustainable industrial parks and residential housing.

Defence

There was a drop in (additional) turnover of some 10 percent for the Defence core area.

In its management of defence research, TNO has been very much engaged in a transition from project management to programme management, which involves the combination of projects. The themes of these research programmes are closely aligned with the policy objectives of the Dutch Ministry of Defence. Approximately two-thirds of the € 68 million defence research budget will be devoted to these programmes.

Defence
– millions of euros

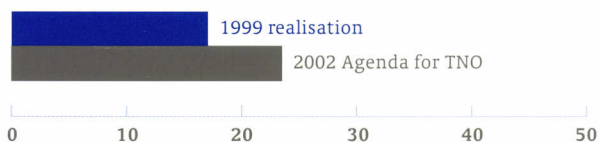


A general agreement has also been reached within the TNO Defence Research Council about the importance for 'civilian' clients of research activities undertaken by the defence research institutes. Not only does such research encourage a spin-in of general industrial technological developments – a phenomenon increasingly yielding benefits for the Dutch Ministry of Defence – but it also allows this ministry to be kept informed about the ever broadening procession of technologies. And this is vital since, according to the conclusion that followed an analysis of TNO's role as principal laboratory, technological know-how is essential for today's armed forces.

Information and communications technology (ICT)

Both in the defence-related as well as the civilian sectors, the ICT area exceeded strategic objectives in terms of market growth, with market turnover growing by 22 percent on 1998.

Information and communications technology (ICT)
– millions of euros



During 1999, TNO proved itself to be even more successful in acquiring business from information-intensive companies, organisations, universities and institutions. Significant customer relationships were developed with leading companies and organisations that both generate ICT (e.g. Lucent Technologies, France Telecom) and companies that use ICT.

For the Ministry of Transport, Public Works and Water Management, work was done on information security, traffic telematics and safety. Other interesting ICT projects were developed for the Ministry of Justice, the Ministry of Home Affairs, and the Registration Board. In 1999, the first gigaport pilot projects in which TNO participated were inaugurated. These projects used the FRIENDS software for developing and validating a platform for on-line services, and VIP for developing and demonstrating video streaming over the Internet. New pilot projects currently being prepared address such topics as electronic tendering, air traffic management and digital patient files. Important ICT developments in 1999 included the next-generation Web-based interfaces, content management, natural language technology, navigation agents and a mobile system for accessing the Internet.

Electronic and physical systems

The 1999 market turnover increased by 3 percent on the 1998 figure.

An intensive joint effort of the various disciplines engaged on 'Electronic and physical systems' has

Electronic and physical systems
– millions of euros



strengthened TNO's profile towards the manufacturing industry. This core area is currently dedicating integral attention to prolonging the life cycles of products and processes, to advancing technology-driven product renewal and to improving processes. This has resulted in a closer relationship with ASML; joint teams are carrying out projects at sub-system, system and technology levels.

The more fundamental questions have resulted in a strengthening of the relationship with universities. With the Delft University of Technology TNO works closely in such fields as optical instrumentation and software engineering. With the University of Twente, a programmatic collaboration has been initiated in the form of the Sound and Vibrations Research Centre.

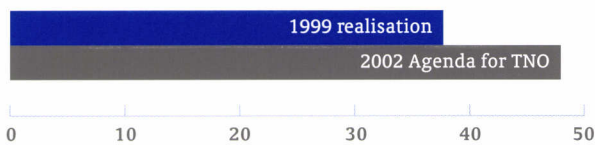
Against the background of ongoing European unification, the active role of this area of expertise will be important within the scope of European legislation and regulations. In addition, the start of the new TNO Space business centre has enhanced the external profiling of TNO within the aerospace market.

Nutrition and food

For 'Nutrition and food', 1999 was an outstanding year, with market turnover increasing by 14 percent.

The 'offensive' interest in the positive aspects of functional, healthy food continues to grow. The market introduction of a margarine with added vegetable materials to lower blood cholesterol levels is a good example. And the ongoing focus on the positive health effects of antioxidants in such foods as vegetables, fruit and tea is another example of this interest.

Nutrition and food
– millions of euros



In addition to this 'offensive' interest, there is also a keen interest in the 'defensive' aspects of food safety. These aspects are reckoned among the spearheads of this core area. The dioxin crisis, along with other calamities, meant that the department engaged on damages and advice was working overtime. Companies could call this department day or night for support in handling an acute problem and thus minimise any threats to public health and adversity suffered by the company involved. TNO is also involved structurally in ongoing programmes for guaranteeing safety throughout the entire food and feed chain.

TNO is one of the first organisations in the Netherlands to be working with both proteomics and genomics technologies that make it possible to measure the effects of substances on the activity of DNA and on the production of proteins in a human, animal or microbial cell.

In 1999, a partnership was formed between the Animal Feed Department of TNO Nutrition and Food Research and the Animal Physiology Department at the Institute for Animal Science and Health in Lelystad; the purpose of this alliance is to enhance both of these organisations' strong market positions.

Since many of the 'Nutrition and food' activities concern life sciences, a large number of projects have been successfully submitted to the new European Union life sciences framework programme.

Prevention and health

The market-focused activities within 'Prevention and health' continue to display a thriving growth in turnover as demonstrated in a rise in turnover of 14 percent.

Although life expectancies in the Western world have increased considerably, new threats in the form of infectious diseases continue to appear. In addition, insufficient exercise, faulty eating habits and an increase in tobacco use require corrective measures. The increasing number of elderly among our population is creating more need for care. Furthermore, complex environmental factors are posing threats to human health and well-being.

Within 'Prevention and health', TNO is developing knowledge and products that will allow us to live not only longer but also more healthy. Needs from both the public and private sectors form the basis for research in this area. The number of requests for patents has risen as well, which provides a good start for achieving the fivefold growth in earnings from patents within the next few years.

New initiatives were taken in 1999 to strengthen knowledge in this area. One of these involved the quality of prenatal and delivery care and the development of methods to assess the quality, efficiency and cost effectiveness of medical treatments. Also taking place was the continued development of advanced models for studying new medicines and methods for supporting the implementation of new types of care.

Prevention and health
– millions of euros



In 2000, TNO expects the core area of 'Prevention and health' to reinforce its position in health and healthcare research.

Labour and labour environment

For this area of research, growth in market turnover fell somewhat below expectations at a very moderate 2 percent.

The NIA-TNO B.V. joint venture was transformed into a new institute known as TNO Work and Employment. There was a noticeable increase in the demand for support to reduce the risks associated with work pressure, stress and RSI within companies, institutions and branch organisations.

The methods developed within this research area for the improved design of ergonomic tools, cabins and chairs have reaped international recognition among producers of professional products. The Long Island

Railroad Company in the United States, for example, has improved the comfort of its passenger seating.

Labour and labour environment
– millions of euros



In 1999, plans were elaborated for arriving at a better working relationship with educational institutions that offer professional training in the field of labour conditions. A better embedding of TNO's position within the international knowledge infrastructure in this field is also facilitated by such factors as the assignments from the Dutch Ministry of Social Affairs and Employment and the European Agency for Safety and Health at Work. Attention is also being focused on certain new areas: integrated management systems, employability, and the effects of ICT on work.

Transport and logistics

The market turnover in 'Transport and logistics' rose by 14 percent in 1999.

TNO was involved in the establishment of the National Traffic and Transport Plan (NVVP). In this regard advice was provided about the long-term strategy for the use of existing infrastructure. TNO also made a major contribution to the concept involving the development of infrastructure corridors.

Transport and logistics
– millions of euros



For the first time, research into new transport systems provided a contribution to turnover. There was a great deal of interest, for example, in underground transport of freight as a possibility for solving problems associated with accessibility and our living environment. For the Dutch Ministry of Transport, Public Works and Water Management, TNO conducted various feasibility projects on underground logistics systems. Yet another important project was 'Architecture for Traffic Management' undertaken for the Transportation and Traffic Research Division.

A behaviour study in a project entitled 'Systems to improve the field of vision for heavy vehicles' showed that the problem encountered by lorry drivers whose

field of vision is impaired when making a right turn can largely be solved by an additional mirror or a camera system.

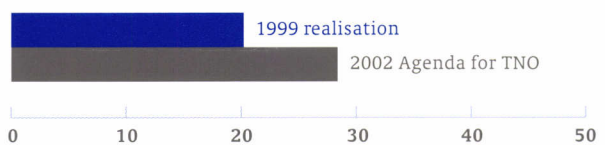
A leading focal issue is and remains collision safety. The considerable upgrading and expansion of the laboratories for collision tests and related research was therefore a significant development during the year under review. The new, modern facilities justify the expectation that the experimental crash laboratory for the international vehicle industry will contribute handsomely to growth predicted for the year 2000.

Building and infrastructure

Market turnover showed a slight fall on the previous year, down just 2 percent.

A year ago, this research area brought together expertise from various disciplines involving safety in underground constructions. Serious calamities in other countries are indicative of the usefulness of such work.

Building and infrastructure
– millions of euros



One of TNO's significant advantages is the fact that it can combine the forces of a wide variety of disciplines to solve complicated problems. Proof of this was the development of new sustainable concepts in a large project involving the efforts of TNO and AKZO. This kind of collaboration (also established with other organisations such as Sunergy, ECN and Shell within the framework of the Deltaplan photovoltaic solar energy project) is expected to grow in coming years. Also worthy of mention is the far-reaching partnership with ENCI (First Dutch Cement Industry) as part of the Prinduceb Project (process and product innovation focused on the sustainable production and use of cement and concrete). Brick preparation, product differentiation and the development of the concrete mixing plant of the 21st century are the main themes in this research cluster.

In a collaboration with HBG, an extensive and ambitious project has been initiated; the goal of this 'Half-time' project is to cut the construction time of housing, public utilities, and civil engineering projects by half.

The Netherlands has taken on the construction of major infrastructural works such as the High Speed Line and the Betuwe Route for trains – in which the Department of Public Works and the Dutch Railways are

playing an important role. Research orders were also taken on and carried out for the construction of covered highways. With existing testing frameworks surrounding large-scale projects having proven inadequate, the demand for TNO expertise is expected to increase. The time is ripe for an effective modelling of the many different phenomena linked to potential calamities.

Subsurface and natural resources

In 1998, streamlining at the Netherlands Institute of Applied Geoscience TNO – *National Geological Survey* (TNO-NITG) resulted in a lower turnover than had been expected. During the past year, these changes were completed and then followed by a recovery that was so effective that the market turnover was more than 30 percent higher than in 1998.

Subsurface and natural resources – millions of euros



A significant development was the completion of the integrated laboratory for geochemical research and analysis that TNO is operating together with Utrecht University. This facility is one of the largest of its kind in Europe. Once reorganisation and selection had taken place, about 200,000 soil samples originating from locations throughout the organisation were collected and are now being accommodated in NITG's soil sample depot.

An order from Van Essen Instruments has resulted in the development of a system in which networks of remote groundwater meters can be controlled and read by means of digital radiotelephony and Internet technology.

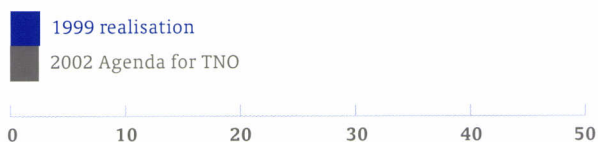
For the Department of Public Works, substantial projects were carried out for charting parts of the Meuse catchment area. Based on these and other projects, TNO reinforced its role as manager and provider of data about the Dutch subsurface. From neighbouring countries, too, an increasing interest in TNO's knowledge of this specialised research area is increasing. A good example is the increasing turnover generated by assignments coming in from Belgium.

Innovation management

Within this core area, market turnover dropped by 18 percent, which was in line with expectations. The renewed positioning of the 'Innovation management'

core area, however, displayed dramatic progress. The development of a renewed TNO Strategy, Technology and Policy (TNO-STB) institute lay at the heart of activities during 1999.

Innovation management – millions of euros



The past year saw improvements in both the quality and quantity of available expertise, with goals centring on occupying a leading position nationally as well as a visible position internationally in technology-related policy and decision-making processes. To realise this objective, the institute benefited from TNO's potential for internal cooperation.

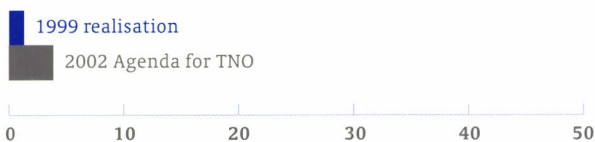
'Innovation management' focuses on four themes: 'New economic structures and processes', 'The dynamics of innovation', 'Decision-making processes' and 'Effects of technology on the consumer and society'.

Public safety

The 'Agenda for TNO' for the period 1999-2002 foresees a rise and turnover in 'Public safety' from nearly € 1 million in the first year to more than € 3.5 million in 2002. In the year under review, market developments were good, with market turnover development right on course.

Contract research for physical security is clearly on the rise. Contacts with the Dutch police have led to a considerable increase in research for a number of police regions.

Public safety – millions of euros



TNO has now arrived at a collaboration agreement with the Dutch Ministry of Home Affairs. This ministry is considering entering into a long-term strategic alliance with TNO. In addition to commercial projects, TNO is also active in the field of public safety, a good example of this being the fact that TNO is one of the co-founders of the Research School Safety and Security in Society.

TNO and the SME sector

Each year TNO is involved, either directly or indirectly, with thousands of SME (Small and Medium-sized Enterprise) activities. Of the 10,000 assignments or so carried out by TNO in 1999, a considerable proportion were undertaken for the SME sector. Of particular significance were the assignments performed for product and trading associations as well as other collectives that represent the SMEs in their business segments.

In addition, TNO coordinated a number of activities for the SME sector. An example is the TNO-SME Initiative for medium-large companies that wanted and were able to take a strategic step into other more competitive technology and market positioning. The year under review saw an evaluation of TNO's SME Initiative amongst 45 of the participating companies. Virtually all those interviewed indicated that the projects had helped in the formulation and implementation of strategy and would again participate in such an initiative should the situation repeat itself.

In order to transfer existing TNO knowledge to the SME sector, Technology Transfer Projects were set going in 1997; by the end of 1999 the second tranche, comprising 25 projects and financed by TNO, was completed.

TNO's position

TNO forms a bridge between fundamental research and its practical application. Due to its tasks and the nature of its function, TNO is a hybrid organisation situated at the hub of various innovation networks and operating in the middle of the government, universities and the corporate sector. This bridging function is something that TNO wants to continue fulfilling. For this reason, the continuation and even intensification of its existing ties with both fundamental research as well as the practical, commercial application of the results of this research is essential. For TNO, it is important to work in a practical business-like way since this not only encourages contacts with the market but is necessary for internal efficiency. In order to enter into close relationships with the business world and to market new technologies, TNO participates in commercial enterprises. These pioneering companies helps TNO contribute to the increase in technologically valuable economic activity.

Collaboration

TNO, in its role as a coordinating organisation within the knowledge infrastructure, maintains solid contacts with such organisations as universities, fellow institutes, and companies in the Netherlands and abroad. TNO participates, for example, in a multitude of alliances within EU projects and in all kinds of consortia. It is not only through its internal coordination of disciplines but also by means of these alliances that TNO is making a positive contribution to preventing the dissipation of the existing knowledge infrastructure. And the government is also relying on TNO to fulfil this role. Nevertheless, in spite of all the efforts being made, the practical situation has shown that systematic long-term cooperation is difficult to establish.

Synergy

New inventions often spring from the interfaces between technologies. The perfect way to arrive at such inventions, therefore, is to stimulate close contacts between the various disciplines.

The multidisciplinary TNO organisation offers outstanding points of departure in this regard. An example of a successful project involving the efforts of several disciplines is Half-Time (see also page 12).

TNO is striving to maximise the added value of a multidisciplinary approach by such means as internal communication policy, meetings and joint projects. Of special interest in this respect are such business centres as TNO Multimedia and Telecommunications, TNO Ageing Research, TNO Space, TNO Pharma and TNO Traffic and Transport. These business centres introduce multidisciplinary knowledge of several institutes to the market. All these efforts have led to many interesting results in 1999.

Alliances

In 1999, BIBRA Ltd. in the United Kingdom became affiliated with TNO, and the European Centre for Product Innovation and Coatings (EPC) in Saarbrücken, Germany, was officially launched. In addition, discussions in regard to systematic collaborations with various other parties were initiated; in international terms, these involved three institutes located in Great Britain, Germany and Singapore.

Commercialisation of knowledge

One of TNO's tasks is the commercialisation of knowledge that the market is not yet adopting on its own. This is occurring in TNO Management B.V. (TMB). As the necessity for ongoing ties with TNO diminishes, the concept of selling these units of participation can be considered. This is what occurred to three TNO companies during the past financial year. These were De Groot Bril B.V., a company specialising in the modelling of oil and gas reserves, TNO Crash Dummy B.V., and Ogle B.V. These last two, both of which are engaged in the production of crash test dummies, were purchased by FTSS, the world's largest manufacturer in this field. The sale of these companies was successful; a long-term research contract was signed with FTSS.

Knowledge development

New knowledge is of crucial importance for TNO. There are many methods for maintaining this influx of new knowledge. Of prime importance in this respect are government investments in the form of basic and programme-related funding. For this purpose, a programme is developed once every four years that is accompanied by annual checks and evaluations of progress. In addition, TNO is quick to capitalise on the possibilities offered by European knowledge development programmes. In this regard, TNO works together with foreign partners. Collaboration with universities is essential for knowledge development; one of the ways in which these alliances are being expressed is the fifty professorships held by employees of TNO. And TNO is also working on its knowledge position by means of joint centres for pre-competitive knowledge development. There are currently twenty such knowledge centres.

The safeguarding of knowledge

There is a clear upward progression in the active patent policy conducted by TNO in respect of the number of patents being requested and granted.

The number of internally reported inventions also shows a considerable rise. For 1999, there were 125 reports (in 1998: 84; in 1997: 33). Inventions are methodically screened and assessed for their strategic and commercial value by Patents and Licensing TNO (PLT). The exploitation of patent rights occurs at a corporate level and lies with PLT.

By the end of 1999, TNO had more than 551 patents to its name and 970 requests were being processed. The number of inventions on which these requests for and grants of patents are based was 314.

Patents form an important focus in reinforcing TNO's strategic know-how position as well as TNO's policy concerning new business development.

Patents and licenses	1999
– internally reported inventions	125
– patents	551
– requests being processed	970
– inventions	314

Future expectations

The continuing positive economic outlook for the Netherlands and the rest of Europe justifies the expectation that the turnover generated by TNO in 2000 can increase by 5 percent or more. With such an increase, TNO will be able to realise the objectives in its strategic plan. TNO also expects, therefore, the establishment of certain strategic alliances with parties in Europe in the years following 2000.

Delft, 10 April 2000

TNO Board of Management

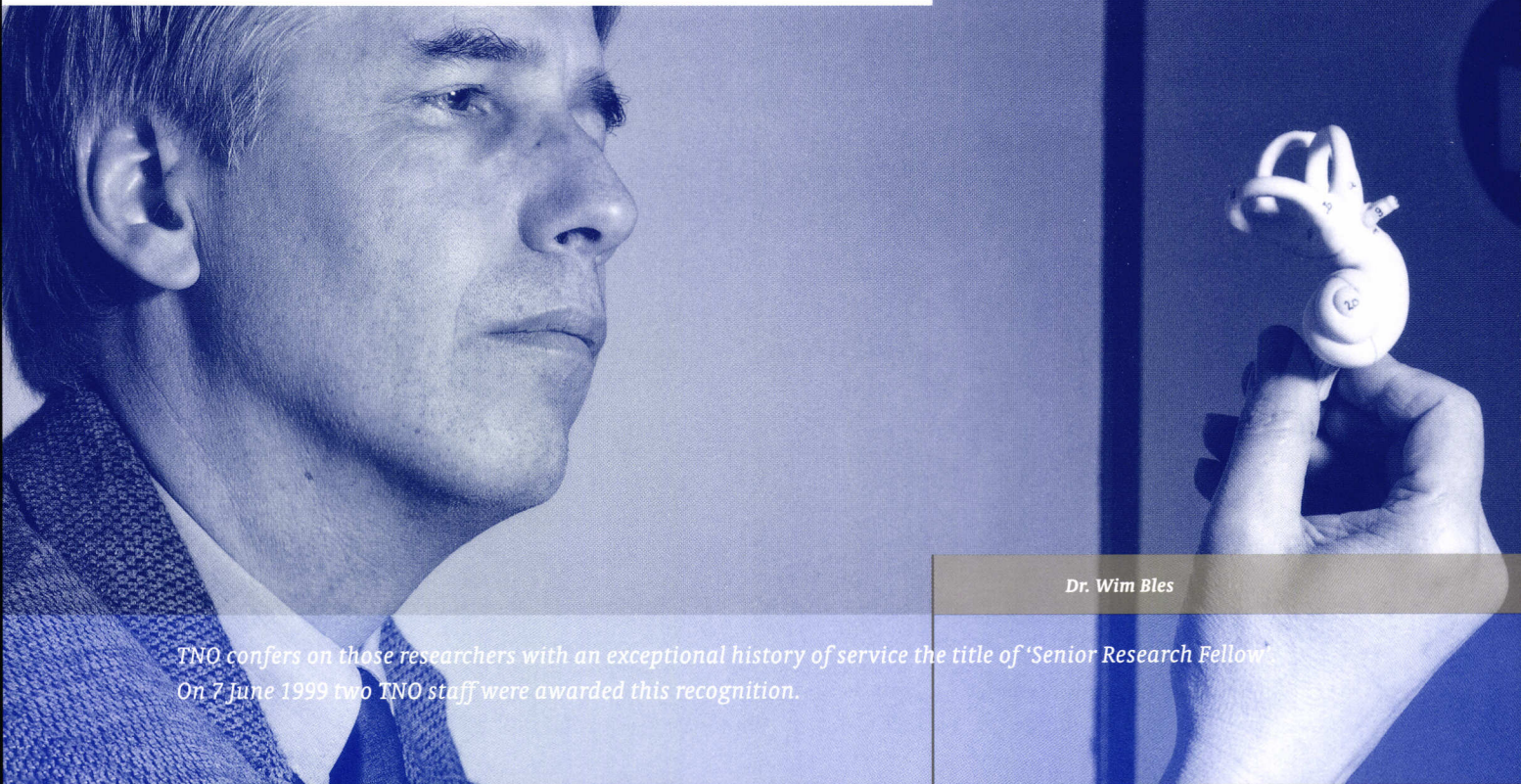
J.A. Dekker, M.Sc., *chairman*

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

Dr P. Folstar

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

Senior Research Fellows



Dr. Wim Bles

TNO confers on those researchers with an exceptional history of service the title of 'Senior Research Fellow'. On 7 June 1999 two TNO staff were awarded this recognition.

Making the connection between air, sea and space sickness - Research into balance has been at the heart of Dr Wim Bles' work since his internship during his medical physics studies in 1969 at the Vrije Universiteit of Amsterdam's University Hospital. Right up until 1989 he worked at the hospital's ear, nose and throat department, although his work at TNO Human Factors had already begun in 1982, three years after achieving his doctorate. Over the past ten years he has been responsible for leading the Balance and Orientation programme within the Work Environment Department, giving full rein in practice to his fascination with balance.

'My internship focused on developing a platform to measure a person's sense of balance. Very quickly I became interested in the process that was taking place in the person on the platform. Balance, it must be said, is an incredibly basic function, although you could probably manage to function without the balance organ because other systems would then intervene. The elementary nature of our balance is shown by the fact that people can become sick due to the disorientation caused by the movement of ships, aeroplanes and spacecraft. It is little wonder, therefore, that the Dutch Air Force and Navy are extremely keen on finding out more about this subject.

'Recently at TNO we have been investigating spatial orientation within a large spatial orientation model, a component of which is a motion sickness model. For years, there appeared to be little connection between air, sea and space sickness – together termed motion sickness. The form they take and the types of motion

causing them differ. The argument had always been that in motion sickness a conflict existed between the information being received by the balance organ and other perceptual information (visual and bodily) or expectations.

'It's all pretty vague. But we have managed to boil it all down in the model to a single conflict. Your senses give you a perception of gravity – your vertical. If that deviates from what you unconsciously expect to happen, then you have conflict. It is a premise that is able to explain a lot of experimental data.

'When motion is accelerated, it's all about expectation. The result of the interaction between what actually happens and what is expected is different for everyone. We still have to clear up why one person is more susceptible to motion sickness than another.'



Prof. dr. Pauline Verloove

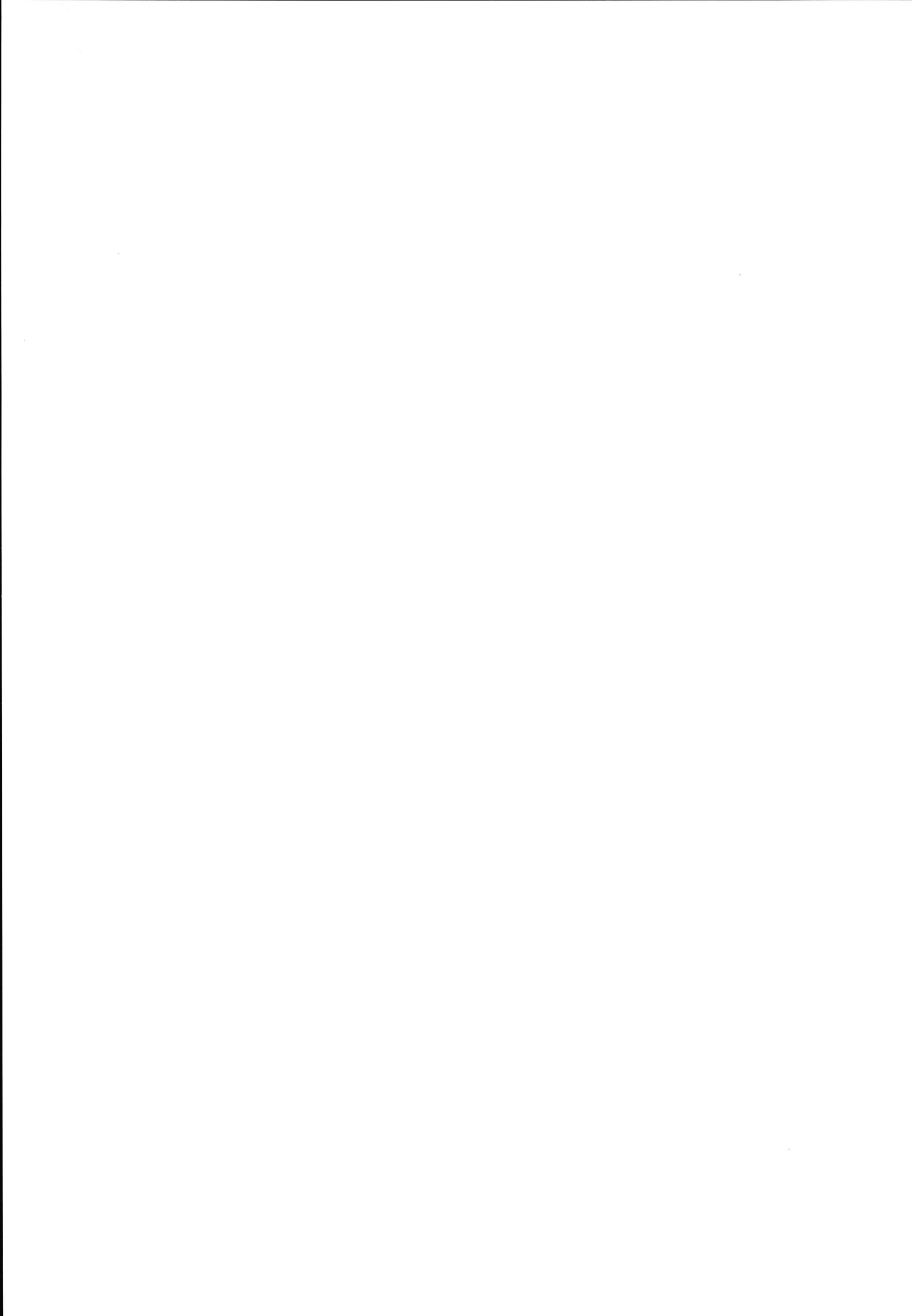
'Prevention is even more essential than cure' – After prof. dr Pauline Verloove graduated in medicine from the University of Leiden, she opted to specialise in paediatrics in 1972, becoming involved in the care of premature babies in the Neontology Department of the Leiden Academic Hospital. This work has provided the springboard for long-term research into premature babies, the subject of her doctoral dissertation. During her curative work, she became intrigued by disease prevention potential, an interest that ultimately resulted in her becoming the head of the Youth Division at TNO Prevention and Health.

'Dutch children are among the healthiest in the world. We have the best-run vaccination programme, the lowest number of teenage pregnancies and a low birth mortality. Youth health care is well organised. It is tempting to be complacent about the focus on prevention research in such a situation. Introducing market forces in order to control costs comes at the expense of prevention: it is not a form of care that is demanded, so there is no market for it, even though you could prove that it is certainly effective and practical in some areas. What can be prevented during a person's youth is beneficial for the rest of their life.

'Prevention must be maintained, otherwise it lapses. Cost-cutting measures in the short-term will wreak havoc in the long run. I think prevention is even more essential than curative medicine. You must start with it as early as you can, namely, when advice is given prior to conception. Ingesting folic acid in the run-up to a pregnancy, for instance, can prevent certain congenital

abnormalities. Thankfully, this advice is being well heeded, just as refraining from smoking or drinking.

'The possibility to investigate potential congenital defects in advance is considerably greater than twenty years ago. While much can be achieved through diagnostics, therapy is still a problem. Therefore, the choice people have is simple: become pregnant or not. And once you are pregnant: continue or abort. For many people this may create a dilemma, but it is much worse to find out afterwards what you could have known in advance. My focus is on the entire gamut of youth health care, and research into premature babies is a good example of the work I am doing. Indeed, since many premature babies appear to have health problems, the prevention of premature births is a matter of high priority.'





TNO in practice

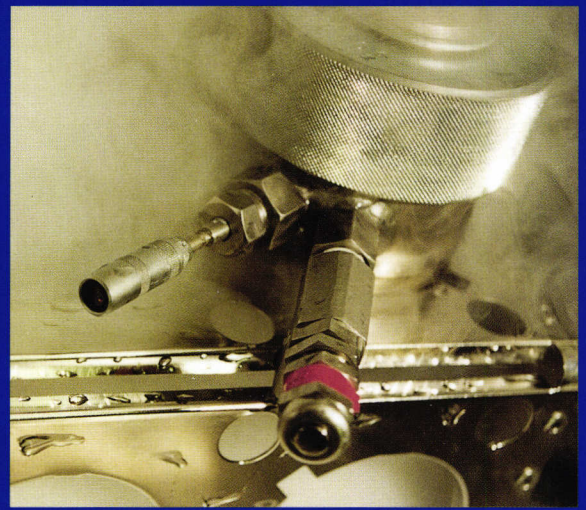
TNO is a corporate contract research organisation with a mission: to strengthen the capacity of business and government to innovate through the application of technological knowledge. It is this mission coupled to its position in the Dutch knowledge infrastructure that enables TNO to form a bridge between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



Liquid biomass fuel for a sustainable future

Hydro Thermal Upgrading (HTU[®]) is the term for the process which turns organic material (vegetation, organic waste, wood) and water into crude oil (biocrude) at high temperatures and pressures. The technology is expected to make an important contribution to meeting Dutch objectives for the production of energy from biomass.

Together with a number of industrial partners, TNO has designed and implemented a pilot plant installation for this process. Now the search is on for the optimal temperature, pressure and reaction time relative to oil yield and the product specifications. For the near future HTU is best suited for use with wet organic waste flows from industrial processes such as beet pulp, spent grains from breweries and coffee grinds. This gives HTU an advantage over burning or gasification which can only be applied to dry or dried raw material. An important advantage of the biocrude product is its potential use as a transportation fuel. In the long term, biocrude could be transported from production facilities in the tropics (wood plantations), where biomass grows quickly, to more temperate regions. An initial application would be to burn it with coal in coal-fired power stations, but after further upgrading it could also be used as diesel fuel for road vehicles.



Carbon dioxide for clean clothing and a cleaner environment

There are many textiles that are too delicate or too susceptible to shrinking to be cleaned in a conventional household washing machine or even by hand. One of the current solutions is the use of perchloroethylene (often referred to as dry-cleaning). However, in view of the new and stricter regulations for the use of perchloroethylene to be implemented in 2007, more environmentally friendly cleaning methods have to be found.

There are many different alternatives. The most environmentally friendly option is the use of carbon dioxide. This 'cleaning agent' places little strain on the environment, and since the textile does not need to be dried, the energy savings might be considerable. TNO is investigating the application of compressed (dense phase) carbon dioxide in the liquid and in the supercritical state as a solvent for use in textile cleaning processes. It is likely that a washing process at pressures between 50 and 75 bar will be able to compete, in terms of cost, with existing methods. Researchers are investigating various pilot-level solutions for mechanical agitation exerted on the laundry, a parameter of major importance. Another important focus is the search for detergents that will enhance the cleaning effect of carbon dioxide. TNO is able to mobilise extensive knowledge with respect to the structure and performance of cleaning systems in projects related to this type of research, and there may even be spin-offs in the field of hard-surface cleaning.

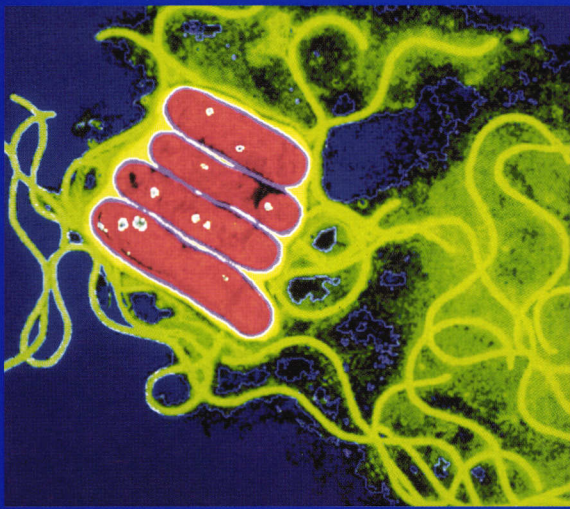


Scenario planning methods and the concept of key resources

When the Directorate General for the Environment at the Ministry of Housing, Spatial Planning and Environment wanted to focus on environmental policy in broader terms, TNO was consulted. TNO's twin task was to develop Scenario Planning and the policy concept of Key Resources by expressing all the diversity of environmental strain in terms of three Key Resources: biodiversity, energy and space.

So, TNO developed a framework of alternative scenarios for long-term environmental policy, or SCALA. In practice, this involves extrapolation to other regions, generations and futures so that the present policy can be determined through contrastive scenarios. A series of workshops took on board the key resources and explored them through various scenarios as well as examined the role of both the Ministry and other actors in developing a policy for sustainable rural development. Sustainability was identified as a crucial component not only for the environment itself, but also in terms of social and economic impact. The tangible benefits of scenario planning can be seen in the creation of 'robust' policy action that can be implemented regardless of which of the four potential future scenarios, as identified in the project, occur. The scenario planning method also enables policy makers to respond promptly and appropriately to any potential uncertainties. All in all, SCALA provides an effective instrument that supports our client in making strategic policy and dealing with uncertainties.



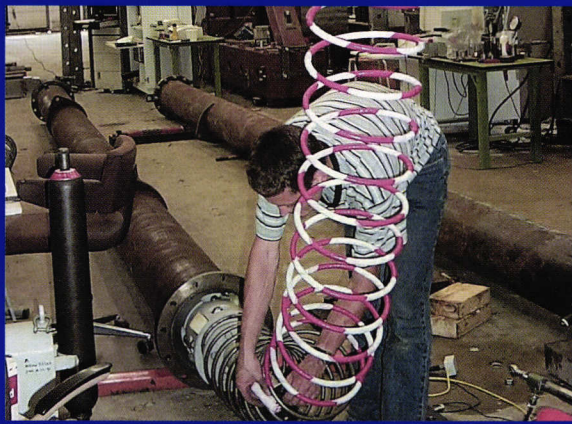


Tapping *Legionella* in a new light

TNO gathered all the available scientific information on *Legionella* for NOVEM, the Netherlands agency for energy and the environment. They were particularly interested in finding out if the prescribed storage temperature of 60 degrees Celsius could be lowered safely. The answer was no, based on the growth and starvation behaviour of these bacteria and their contamination risk.

But the information collected by TNO brought more to light. The conventional view is that the growth and propagation of this commonly occurring bacteria takes place in lukewarm water. But this theory does not explain all the incidence of the disease. One possible hypothesis that might actually be valid assumes that protozoa function as a carrier of *Legionella*. The protozoa eat the bacteria, which then survive as parasites inside the protozoa, proliferating and becoming a veritable bacteria bomb in this protected environment. That is why measuring the source of a disease may produce a negative result, even though *Legionella* is present in large numbers. This knowledge is not only essential to the approach taken to carry out measurements, it is also essential to the design of new hot water tap systems. The spread of *Legionella* via protozoa directs scientific attention onto the films of organic matter inside the equipment, the places these organisms like to linger. An evaluation of existing hot water tap systems showed that the risk of disease could not be ruled out for all types of equipment.





Good vibrations for the world's largest wheel

The British can be proud of their 'British Airways London Eye Ferris Wheel'. This Ferris Wheel, and its 135-metre diameter, is remarkable in many respects. The builder, Hollandia B.V., and their advisor, TNO, also have reason to be suitably proud.

TNO assessed the risks of construction using fault-tree analysis and gave advice on safety measures for the extraordinary structure. Buckling analyses were carried out on the cast steel spindle in order to assess the probability of fracturing. An inspection protocol was proposed for a number of the fatigue-susceptible components. The dynamic behaviour of this pre-eminent wind scoop was also examined. Gusts of wind can easily cause such a fragile construction to oscillate, which is detrimental to the wheel's durability and creates a sense of insecurity. Preliminary dynamic calculations indicated that extra dampers would need to reinforce the original design of the London Eye. The solution lay in tubular dampers, placed diagonally across the rim. A four hundred kilo mass, attached to coiled springs at both ends, moves back and forth inside each of these eight metre long tubes. The weight helps dissipate the London Eye's oscillations.



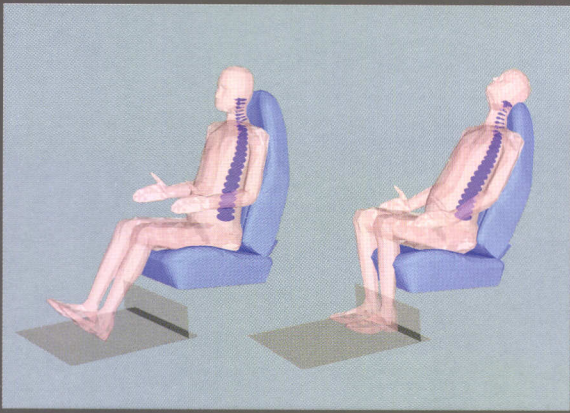


Research into the eating habits of ethnic minorities

Relatively little is known about the eating habits of ethnic minorities in the Netherlands. That is why the Ministry of Health, Welfare and Sport assigned TNO to look into the eating habits of Turkish and Moroccan eight-year old children and their mothers. A group of Dutch mothers and children was included in the study in order for researchers to be able to draw meaningful comparisons. The results were also compared with the recommended intake of nutrients and the official publication 'Guidelines for Healthy Nutrition'.

Results showed that, in terms of nutrient content, what Turkish and Moroccan mothers and their children eat is actually more in line with the guidelines than their Dutch counterparts. They use less saturated fat, for instance. Nevertheless, there are also points of concern that apply specifically to the Turkish and Moroccan group in which women and their children consume relatively little vitamin B1, calcium and iron. Anaemia is common among Turkish mothers. Being overweight is common among all women; more than one quarter of Dutch and Turkish mothers and more than half of Moroccan mothers are severely overweight. One finding worthy of note is that Turkish and Moroccan children are more likely to skip breakfast than Dutch children. This information provides the Ministry with a tangible starting point for policy development. The report also recommends that measures be taken that might help to prevent and reduce obesity.





Crash Safety Centre: a testing patch for world players

Now that the Crash Safety Centre has been redesigned and expanded, TNO has one of the most advanced independent test labs for crash safety in the world. One of the new facilities is the servo-hydraulic reverse sled, which can subject the test object to forces up to one hundred g. However, it is the accurate execution of tests below five g that makes this installation unique. The ability to simulate full-scale crashes is yet another strong point; this allows improvements to components to be tested without having to crash whole cars.

Another novelty is the 'whiplash dummy' that has been specially designed for simulations of crashes from behind and for assessments of the protective effect of headrests and car seats. This dummy is expected to contribute to new European regulations for preventing whiplash injuries. Nowadays, computer simulations play an important role in assessing safety in the first stages of vehicle design. In addition to validated models of crash dummies, TNO now produces real human body models. These models are appropriate for frontal, lateral and rear strains as well as those coming from directions in between. They allow efficient analysis of aspects such as the variation of body sizes, and the effects of muscle activities. Detailed human models allow injury to be analysed at tissue level.





More efficient use of Dutch infrastructure is possible

The Netherlands faces the paradoxical challenge of coming up with a solution for congestion on the roads whilst at the same time limiting large-scale expansion of the motorway network. The answer will have to entail the most efficient possible use of the existing infrastructure. The application of information and communication technology can contribute to this, as can small modifications to the infrastructure and a focused transport policy. Nevertheless, the risk exists that if these resources are not coordinated sufficiently, we will actually end up with the opposite effect.

Thanks in part to the contribution of design studios pooling expertise from various organisations, TNO has been able to sketch a realistic and comprehensible strategy for utilising the infrastructure in the publication 'Balanced use – the strength of cohesion.' This document pinpoints the logical links between traffic expertise, organisation and ICT, so that all the parties involved can work on the realisation of an efficient approach to utilisation in their particular region. Together with experts at the Ministry of Transport, Public Works and Water Management, TNO is involved in the development of an Architecture for Traffic Control (AVB) which helps to achieve a coordinated set of measures. A certain degree of standardisation in the application of tools derived from the AVB will help to reduce costs and improve cohesion. Now that a platform has been established for all those involved, measures can be implemented more cheaply and more quickly.





Cyberwar: A new Achilles' heel?

Modern Western society depends greatly on its information and telecommunication infrastructure. In theory, sinister countries and groups could trigger economic and social disasters by knocking out communication networks and information systems. So, securing this infrastructure is an important task for National Defence.

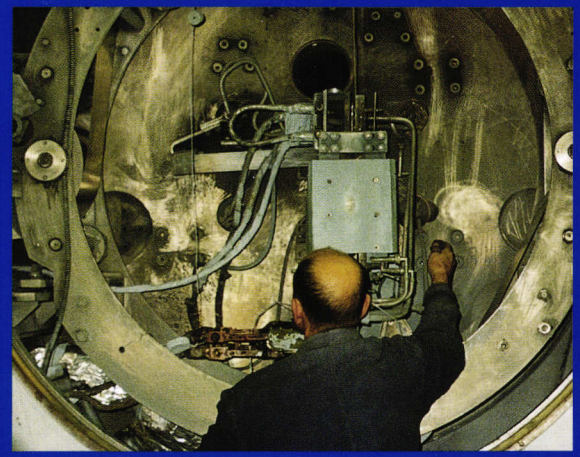
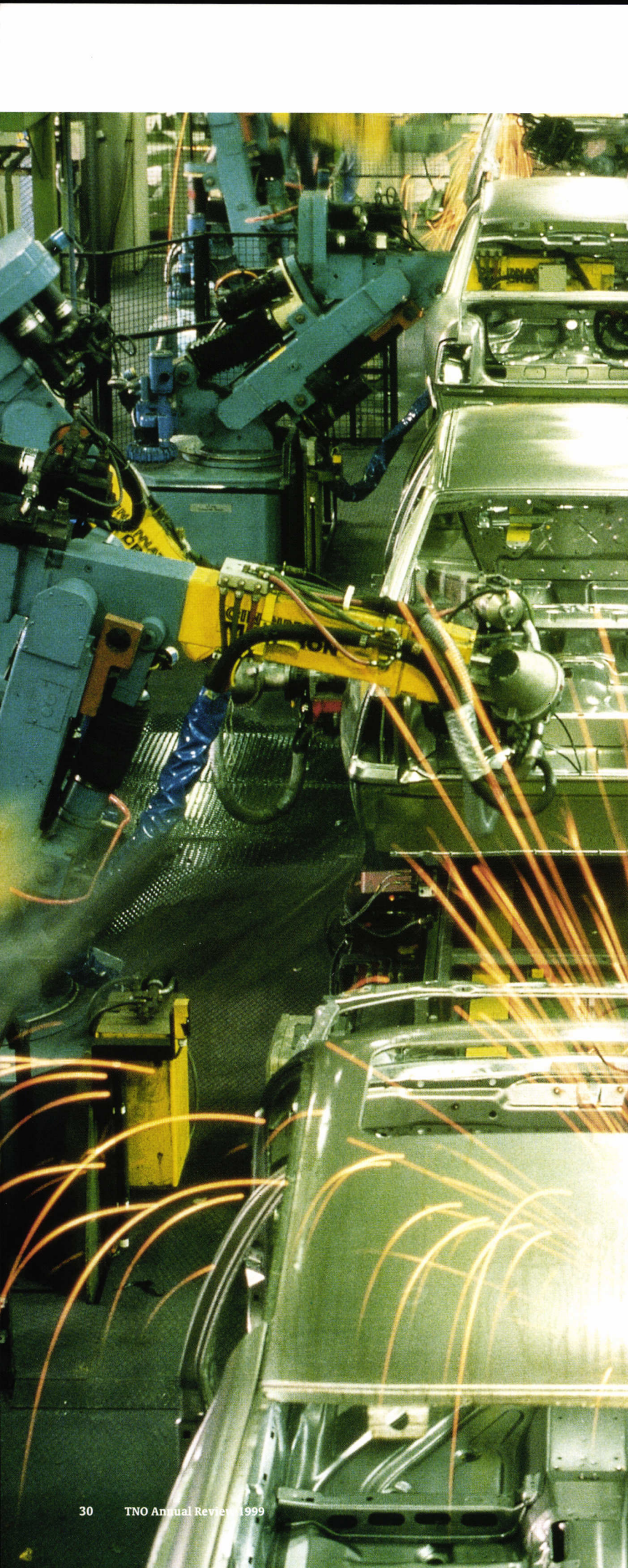
TNO has carried out a number of studies to clarify what 'Information Operations' actually means to Dutch Armed Forces operating within a coalition. An important TNO task is to increase awareness of the 'Cyberwar' threat through lectures, publications, and the interdepartmental Infodrome project. One of our most important assignments at this time is to develop the notion of a secure critical information infrastructure for the government. TNO also considers it advisable that an adequate alarm centre is set up to resist potential attacks from Cyberspace and to distribute essential information to those concerned in this kind of a situation. TNO is taking on the challenge in technological terms, too. The challenge lies in developing new tools to protect information. Additionally, the TNO 'hacker/intruder team' can help to bolster defences as they try to seek out weaknesses in the security posture. Early detection of intruders in information networks also deserves investigation. This would allow countervailing measures to be taken such as sending intruders into the 'Cyberwoods' with false information.



Technical feasibility of a natural gas engine signals a breakthrough

The quality of petrol and diesel is virtually consistent across Europe. The same cannot, unfortunately, be said of natural gas. A fuel quality that fluctuates from one place to another makes the starting and running of natural gas engines difficult. This is rarely a problem for bus companies since they tend to use their own natural gas filling stations. But drivers of passenger cars cannot be expected to refuel in the same place every time.

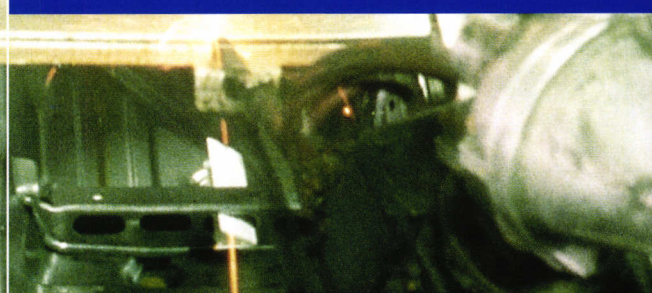
In an EU project, TNO, together with BMW, Fiat and Volvo, faced the task of removing this obstacle to make way for the breakthrough of an Otto engine run on natural gas. Because the achievement of consistent natural gas quality is, as yet, a utopian dream, the solution had to lie in the automatic detection of the quality of natural gas in the tank. The ion-sense measuring principle provides the solution. Measurement of the current between the electrodes and the spark plug gives an indication of how well the combustion is going. This measurement signal is transmitted to the engine management system, which uses the information to ascertain the optimal mixture of air and fuel for the engine, given the fuel quality. The engine management system then translates this information into a control signal for the regulation of fuel injection. The programming of this software algorithm for fuel regulation allows natural gas cars to refuel – and drive – all over Europe without running into any problems. This represents the removal of the final obstacle standing in the way of a breakthrough in natural gas engines.



Hoogovens Steel: Vacuum vaporisation of strip steel zink

Automobile manufacturers use zinc coated steel strip, of which Hoogovens is a supplier, to guarantee long-lasting corrosion resistance on vehicle bodywork. This steel strip is immersed in a basin of molten zinc and is covered with a zinc coating of between 6 and 10 μm . However, this coating causes problems during the production process. Since it contaminates tools during deep drawing, the electrode wears out more quickly in welding, and recycling is made more difficult. The solution lies in the introduction of a thinner layer of zinc but this requires an alternative method of application.

TNO was assigned the task of getting to grips with this. However, the application of a thinner layer must not be allowed to reduce the corrosion resistance. Physical Vapour Deposition (PVD), the vacuum vaporisation of the coating, may, in principle, provide the solution. This technology not only allows the thickness of the coating to be precisely controlled but also facilitates the amalgamating of zink-magnesium, for instance. However, these opportunities are not without their challenges. Regulating the thickness of the layer as well as the concentrations of the metals is highly complex. In developing the application technology, TNO has been working with the Latvian company, Sidrabe, whose experimental data have laid the basis for TNO to develop, for instance, the modelling for the requisite vaporisation system.





The fate of premature babies

Around 1975, intensive care for premature babies was initiated in the Netherlands. The questions of how these children fared afterwards and the outcome of the care remained unanswered. For this reason, POPS (Project On Pre-term and Small-for-gestational-age infants) was initiated in 1983, a project in which TNO plays a key role. All 1300 children born within the first 32 weeks of pregnancy and weighing less than 1500 grams at birth in 1983 were monitored throughout childhood as part of this research.

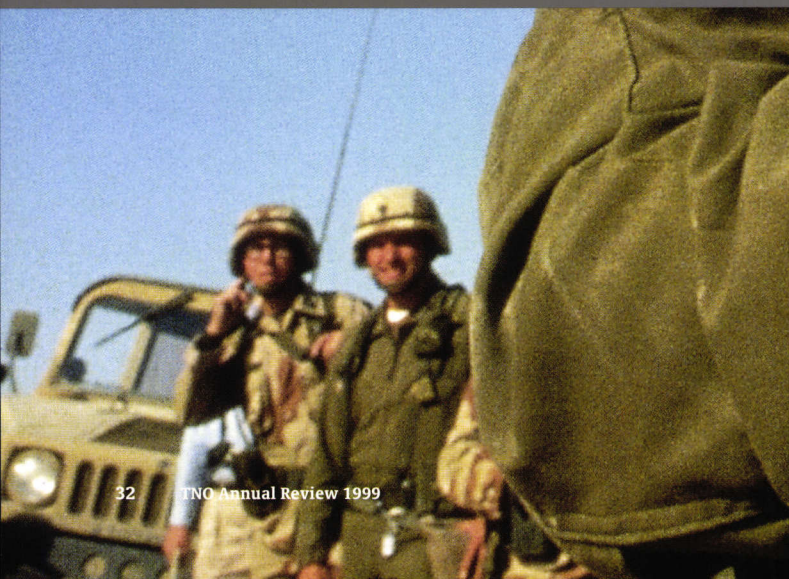
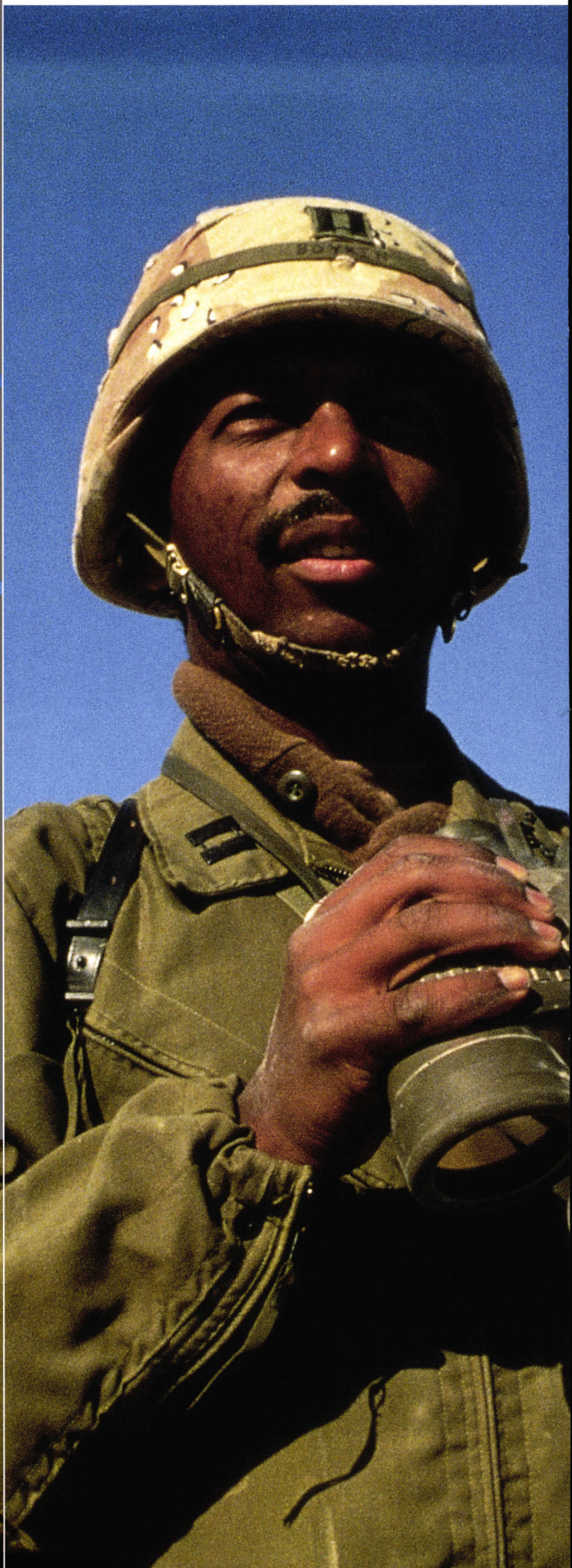
It was not just the number of these births and the mortality data that were gathered; the lives of these children were thoroughly examined at the ages of 2, 5, 9, 10, and 14. Many aspects were investigated, from basic motor skills to IQ and social behaviour. The picture that emerges is reassuring: most have survived and are doing well. However, only a quarter of them are growing up free of problems. The others have learning or behavioural problems or are struggling with some other type of physical defect. With knowledge derived from the POPS research, the care of premature babies has been modified in some respects. At the end of the eighties, intensive care was concentrated in ten intensive care units, for instance. This helped reduce the mortality of these tiny patients from 30 percent to 10 percent.

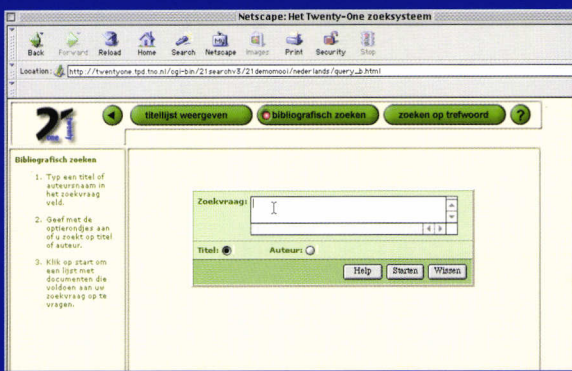


What role does nerve gas play in Gulf War syndrome?

What actually happened back in 1991 in Kuwait? The fact is that years after the Gulf War, thousands of veterans are still suffering from muscle pain, chronic fatigue, drowsiness and mental deterioration. There is no explanation for it. Was it related to depleted uranium in the ammunition, or the burning oil wells, or perhaps the vaccinations?

Via the Medical Command of the US Army and others, the Veterans Association assigned TNO to carry out scientific research to get to the bottom of this mystery. One of the most important questions that needs answering is whether exposure to low doses of the nerve gas Sarin was a contributing factor. The gas may have been released when the US Army blew up an Iranian rocket depot. TNO is using its own, revolutionary method of dosimetry to figure out the answer to this question. It was already known that a slowdown in the activity of the enzyme cholinesterase in the blood points to exposure to nerve gas. However, until now the measurement of this slowdown in activity has been diagnostically unreliable and dosimetrically imprecise. TNO's new method uses fluoride ions to pick up the nerve gas from the cholinesterase for further analysis, thus enabling chemical processes to determine with extreme accuracy whether exposure has taken place and, if so, to what degree. Whether nerve gas is confirmed to be a contributing factor or eliminated, the research may bring us a step closer to explaining the elusive Gulf War syndrome.





Intelligent search technology for a healthier Internet environment

Generic search engines on the Internet make their selections based exclusively on one or several key words that the user enters. The key word 'bank' will produce a large number of irrelevant titles or sites containing this key word. At the same time, all kinds of information that may be interesting to the user remain hidden, because that particular keyword is not used. For 'bank' this could be information on 'sand bars', 'finance', or 'billiards'.

TNO's search engine Twenty One does not have these pitfalls. This search engine makes a number of Dutch environmental websites accessible to the people at the Ministry of Housing, Spatial Planning and Environment as well as to other Dutch Internet users. Intelligent search technology ensures that the user does not get any 'noise' (needless information) but does get 'silence' (useful information not containing the keyword). The technology distinguishes itself from its counterparts because the search engine uses a lot of knowledge about language, which, in a way, allows it to 'read' texts. The system can relate words that together make up a meaningful whole. Through language technology and the Ministry's extensive thesaurus, Twenty One understands the connections between related terms. Tangibly, this means that the user looking up 'water pollution' will also find 'pollution of the water', and via the thesaurus, 'river silt'. A huge advantage of this promising technology is the simple, effective and intuitive search method. The ability to do cross-lingual searches (asking a question in Dutch and getting an answer in English) contributes to the potential of this technology.

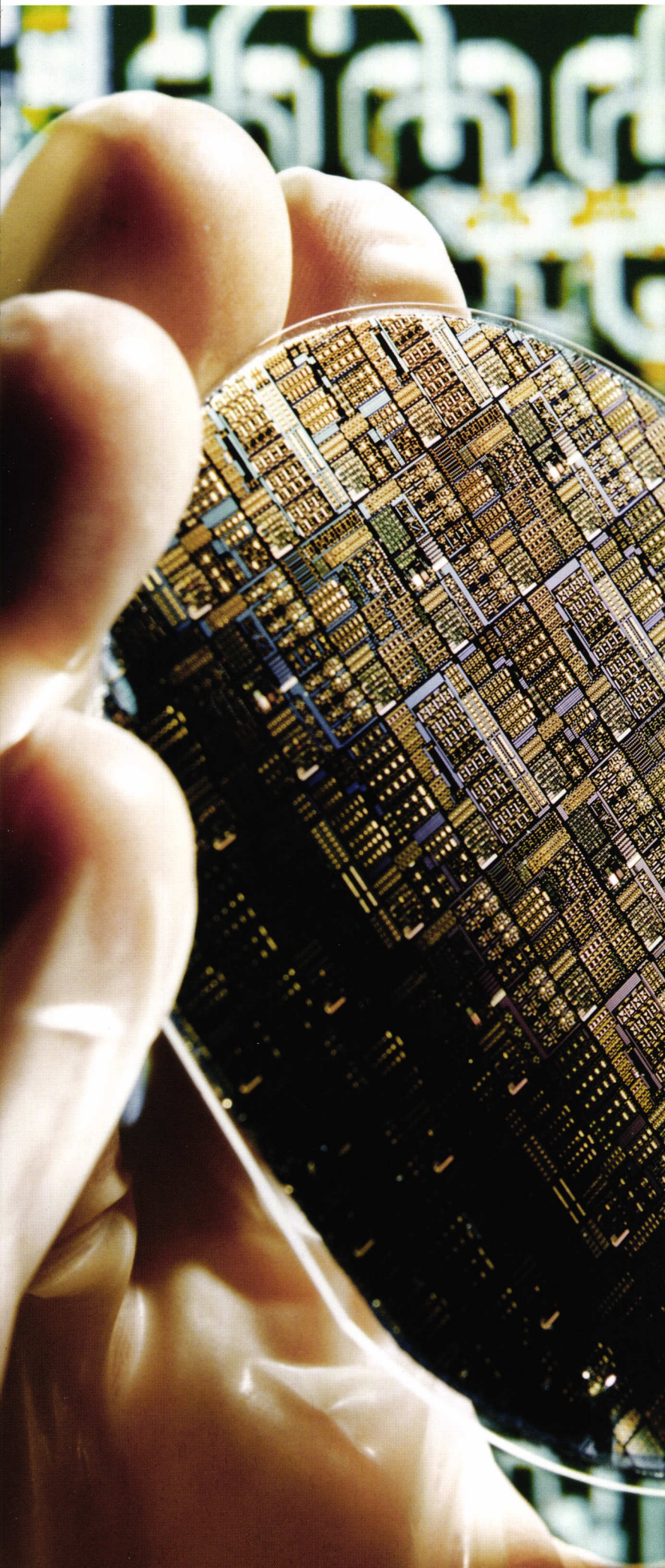




Intelligent cameras and sensors in the service of safety

A key Dutch concern these days is safety in society. In this respect, the introduction of camera systems in public areas is being followed with great interest. TNO dedicates much effort to the development of techniques to promote safety. For instance, a recent technical innovation demonstrates reliable detection of suspicious individuals. By means of a camera-based classification method, an alarm system can quickly assess whether a suspicious moving object is just a cat strolling by or maybe a burglar. These developments will help to advance the reliability in security systems, thereby reducing the number of false alarms.

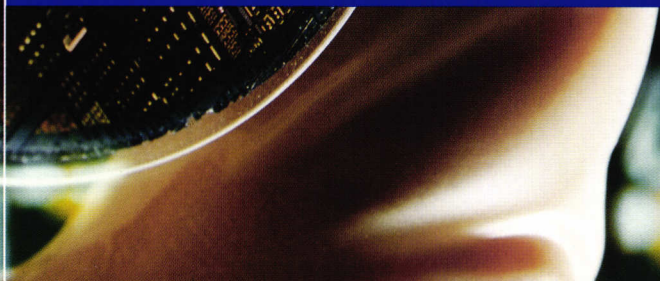
Moreover, in the near future, intelligent camera systems will be able to recognise aggressive actions or behaviour by incorporating different sensors. Various types of sensor could inform a camera system, for example about the presence of yelling, chemical odours or metallic objects. By combining these information streams, the camera system is capable of concluding whether the action is aggressive or not. If so, the camera system sends relevant scene information to the security control centre enabling the guard on duty to take appropriate measures. By only sending relevant information to the control centre, the guard can keep track of a large number of areas simultaneously. An additional capability of this system is that the intelligent cameras can cooperate with each other. One of the merits of communication between cameras is that they can 'follow' suspicious persons across large areas, one camera taking over from the other. Besides their usefulness in surveillance, these systems can also benefit traffic control as well as the processing industry.



Collaborating with ASML on new generations of wafer scanners

About seventy TNO staff are working on the development of a 'level sensor' module to be used on the new generation of ASML wafer scanners. These are the machines used to make chips. The wafer scanner projects a slide of the chip design through a lens system onto a silicon wafer, a process that demands extreme precision. The level sensor measures the distance to the silicon wafer to the nearest nanometer for focusing before exposure takes place. Should the positioning not be entirely accurate, the level sensor allows it to be corrected during the production process.

This huge project serves to illustrate the closeness of the collaboration between ASML and TNO. The relationship started with a small engineering assignment several years ago, and has since developed into one of our core businesses. TNO is working on several related projects at once. A separate research group is developing a hoisting device that will allow the lens system for the new machine to be mounted and dismantled with extreme precision. While the machine's development is still in full swing, a group of researchers in the Next Generation Lithography project is already looking further ahead and exploring the limits of what is physically possible. Their investigations will culminate in the development of a new test device incorporating the latest insights generated by the experiments.

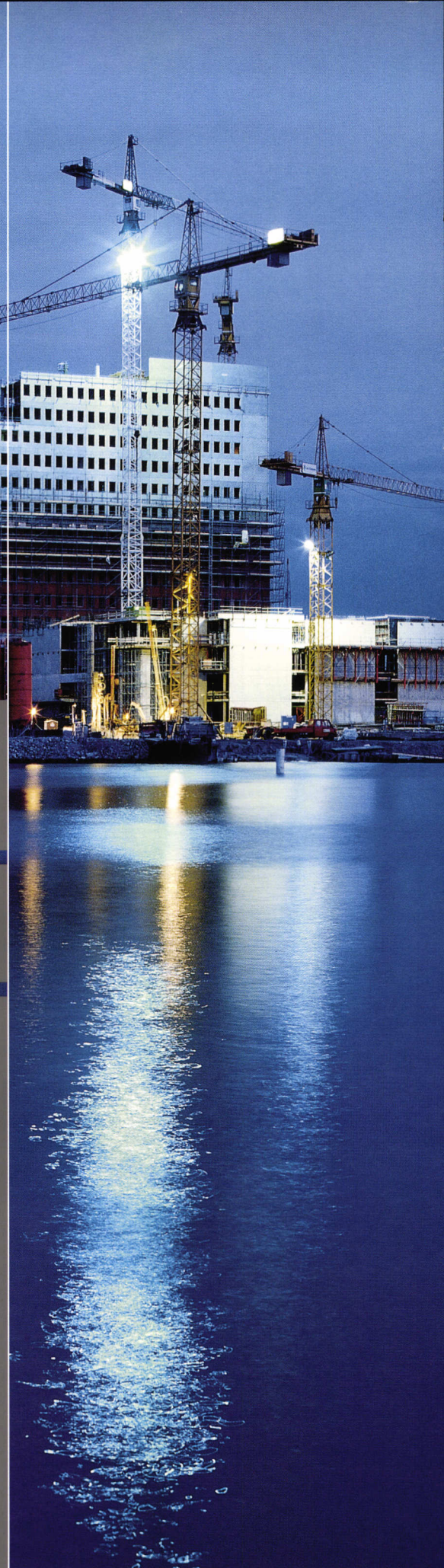


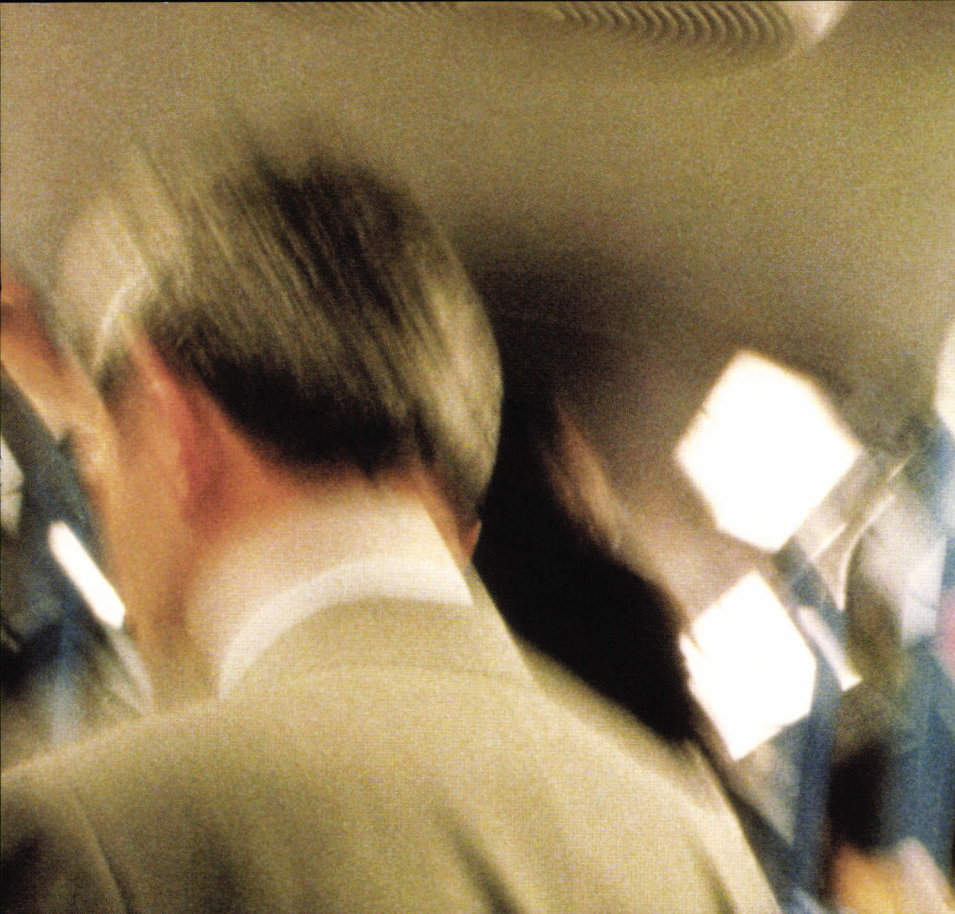


Halving the time by building twice as fast

The Half-Time project has set itself an ambitious target, namely to halve the time it takes the HBG, *Hollandsche Beton Groep nv*, to complete residential, commercial and industrial construction work and road and waterway projects.

HBG and TNO went into this research project together. They took a multidisciplinary approach by dividing the project into three groups of dedicated subprojects looking at organisational, technical and ICT aspects of the building process. In the first group, 'Organisation', subprojects have been set up focusing on types of contract, logistics and industrial processes. The second group of subprojects contributes to technical solutions such as alternative blends of concrete, methods of asphalt processing and positioning methods. The integration of information technology and knowledge management is an essential element of the approach in the third group of subprojects which includes the use of 3D and 4D CAD, virtual environments, and the use of the intranet for document control and workflow. Changing the mentality of the personnel is equally essential. The technical and organisational modifications serve both to illustrate and justify an innovative construction perspective. The far-reaching and integrated approach may not only produce savings in terms of production time, but may well also reduce environmental strain. Secondary benefits will include a qualitatively better end result, reducing inefficiency and waste in the process. The results of the project so far are already demonstrating in practice that the selected approach works.



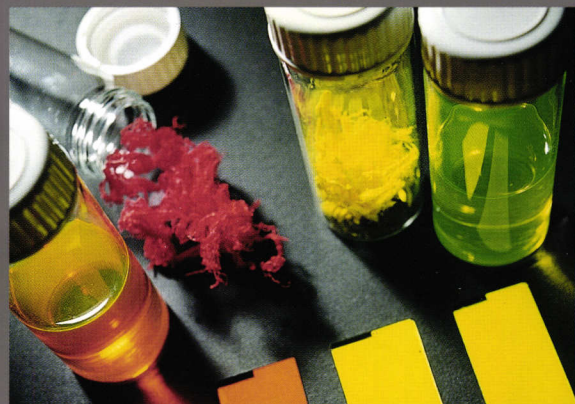


The Ergomix solution to New York commuter comfort

Users of New York's commuter trains do not only use their train seats to sit on, they also try to read, work, eat, drink and sleep in them. The designers of the new seats tried to take all of these factors into account when coming up with the new design.

TNO's Ergomix proved to be an ideal tool. This design instrument allows actual test subjects and their activities to be taken into account in the preliminary stages of design. Ergomix uses two cameras: one observes the test subjects carrying out their usual activities and the other takes shots of the provisional design. By mixing both images a 'living' sketch is created, in which modifications can be made and tested immediately. Real situations are used as the basis for optimising accessibility, height, view, legroom, posture and freedom of movement. The final design of the seats for American commuter trains was based on observations and measurements carried out by TNO on two thousand passengers. The fact that certain measurements were taken with the Ergomix reduced the design time significantly, which in turn kept the cost of the design process down. That is, of course, good news for the train manufacturers. But it is also very good news for the commuters of New York, who can look forward to a comfortable ride in a train seat that is optimally suited to their individual postures and movements.

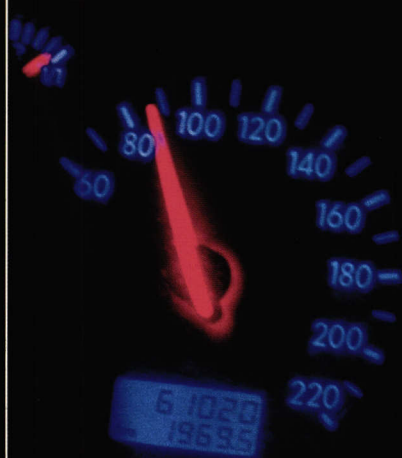




Polymers and electronics, a great combination in prospect

The technical qualities of intrinsic conductive polymers as a substrate for memory chips still lag behind those of silicon: they have lower speeds and poorer durability, and there is more extraneous noise. On the positive side, though, is the fact that polymers are simple and inexpensive to process, which should, in the future, lead to a cost of production many times lower than for silicon chips. Herein lies the enormous potential of plastic chips on a flexible foil. Plastic chips will, for example, be able to replace barcodes and security tags at the same time, and will therefore be suitable for use on supermarket products.

In order to facilitate research, TNO is synthesizing semi-conductive polymers on an intermediate scale. TNO researchers are also preparing illuminated screens from conductive polymers for marketable instrument panels. These so-called polyLEDs rival LCD screens. Advantages include high contrast and clarity and low energy consumption, plus angle-independent visibility and the potential to produce large screen areas. TNO is working hard on the translation of mere promises into actual applications.





The Lagoon: A natural ecosystem for dolphins

The Lagoon is the showcase of the Dolfinarium in Harderwijk, the Netherlands. In this new habitat, the amusement park would like to create a perfectly natural ecosystem for fifteen dolphins as well as a number of sea lions and seals. The sea mammals share real seawater, to which no chemicals have been added, with crustaceans and shellfish, fish and microorganisms. This kind of a natural ecosystem requires a subtle balance between the various links in the biological chain since the density of animals in the Lagoon is far greater than it would be in the ocean. Consequently, the number of purifying bacteria is too small to clean up the waste, and this causes turbidity of the water.

TNO is working in cooperation with the Dolfinarium to find purely natural substances that will help to achieve a natural balance and clear water. The criterion is that no life form may be removed from the ecosystem. Instead, other life forms should be encouraged. The introduction of copopods contributes to improved water clarity. Extra bacteria, initially worked from special filters, are now doing their work even better in the sand at the bottom of the Lagoon. TNO is looking into the use of the filtering capacity of mussels and the removing of nutrients by sea lettuce, as a means of gradually re-establishing the natural, clear water equilibrium. The crowning glory of the work is three healthy baby dolphins that were born recently. What better indication could there be that the animals are comfortable and contented?

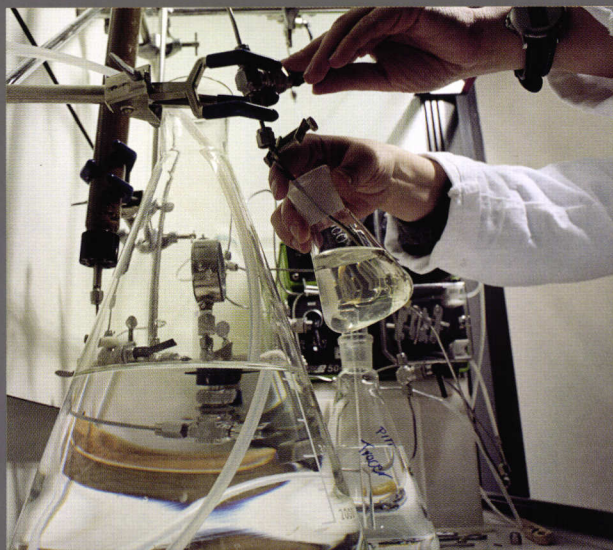


A polarisation filter for better detection of land mines

Armed conflicts often leave behind their traces in the form of land mines long after they are over. The only solution currently available is to clear them manually, which takes a lot of time and costs a lot of money. TNO is working on ways to do it more quickly and safely. It plans to combine several techniques to produce new close-in detection equipment for individual mines such as metal detection, ground radar, vapour detection and thermal infrared.

The addition of a polarisation filter can improve the effectiveness of thermal infrared cameras, particularly in areas with dense vegetation such as Mozambique and Cambodia. The filter works on the principle that rough natural soil does not polarise light, whereas a flat or artificial surface, such as a landmine, does. This type of surface will therefore produce a variation in the intensity of reflected light as the polarisation filter changes position, indicating the possible presence of a mine. To optimise the difference, the camera takes fifty shots in rapid succession with a different polarisation filter position each time. The degree of the variation in intensity is then determined for every picture element. The data from the other techniques is combined with the findings of the polarisation filter and translated into a message for the mine clearers. Under test conditions, the probability of land mine detection increased by 10 percent when the polarisation filter was used. The number of false alarms also remained low; the number of false alarms on high detection percentages dropped by a factor of three.





PITT: Tracing pollution sources accurately

Any liquid that is heavier than water is a major problem in soil sanitation. These so-called Dense Non-Aqueous Phase Liquids (DNAPLs) flow downwards through groundwater until they nestle on a semi-permeable or impermeable layer where they slowly dissolve into the groundwater. The result is a near interminable pollution of the groundwater.

What is needed is a precise determination of the location of sources, but no technique has been available up to now that could do it at an acceptable cost. That is why TNO developed the Partial Interwell Tracer Test (PITT) during an onsite pilot project. This method is based on the different behaviour of various tracer substances in relation to the DNAPLs. Reactive tracers such as alcohols will disperse through the groundwater and the DNAPL. A conservative tracer like bromide, however, does not react with DNAPLs, and will therefore flow more quickly and break through to downstream locations more quickly. By measuring the speed at which both tracers break through, the location of the contamination and even the amount of contaminating substance present can be deduced. This greatly improved characterisation of DNAPL contamination zones allows for a much more effective and inexpensive cleanup solution.





Food, mood and behaviour: the chemistry of emotion

Brain function still contains many secrets. It is, however, becoming increasingly apparent that food may influence our emotional and cognitive behaviour by acting upon neurochemical processes in the brain. TNO is among the frontrunners researching the relationship between food, the central nervous system and behaviour. Take, for instance, the study being carried out into the effects of alpha-lactalbumin on the serotonin system. Serotonin is a neurotransmitter that influences mood, performance and sleeping behaviour. The amino acid tryptophan is needed for the production of serotonin. The human body cannot produce tryptophan on its own - available tryptophan and serotonin in the brain partly depends on dietary sources. It is not enough that the food contains tryptophan; the substance must actually compete with other amino acids in plasma for uptake into the brain.

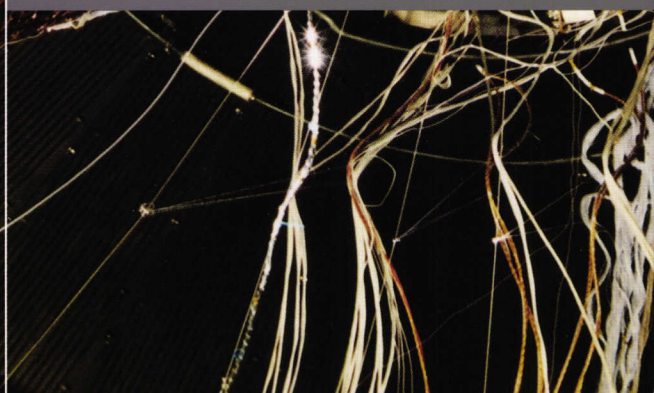
TNO researchers have therefore been looking for ways of shifting the ratio of plasma amino acids in favour of tryptophan. According to some, the current solution entails a carbohydrate-rich, protein-poor diet, but this is not without disadvantages. A new approach involves the use of the tryptophan-enriched protein alpha-lactalbumin. Tests have shown that consumption of twenty grams of alpha-lactalbumin can increase the tryptophan ratio by 46-48 percent - an extraordinary performance for an ordinary food. New research being carried out as part of the Target Nutrients Project aims to clarify further the relationship between food, the central nervous system and emotional and cognitive behaviour.

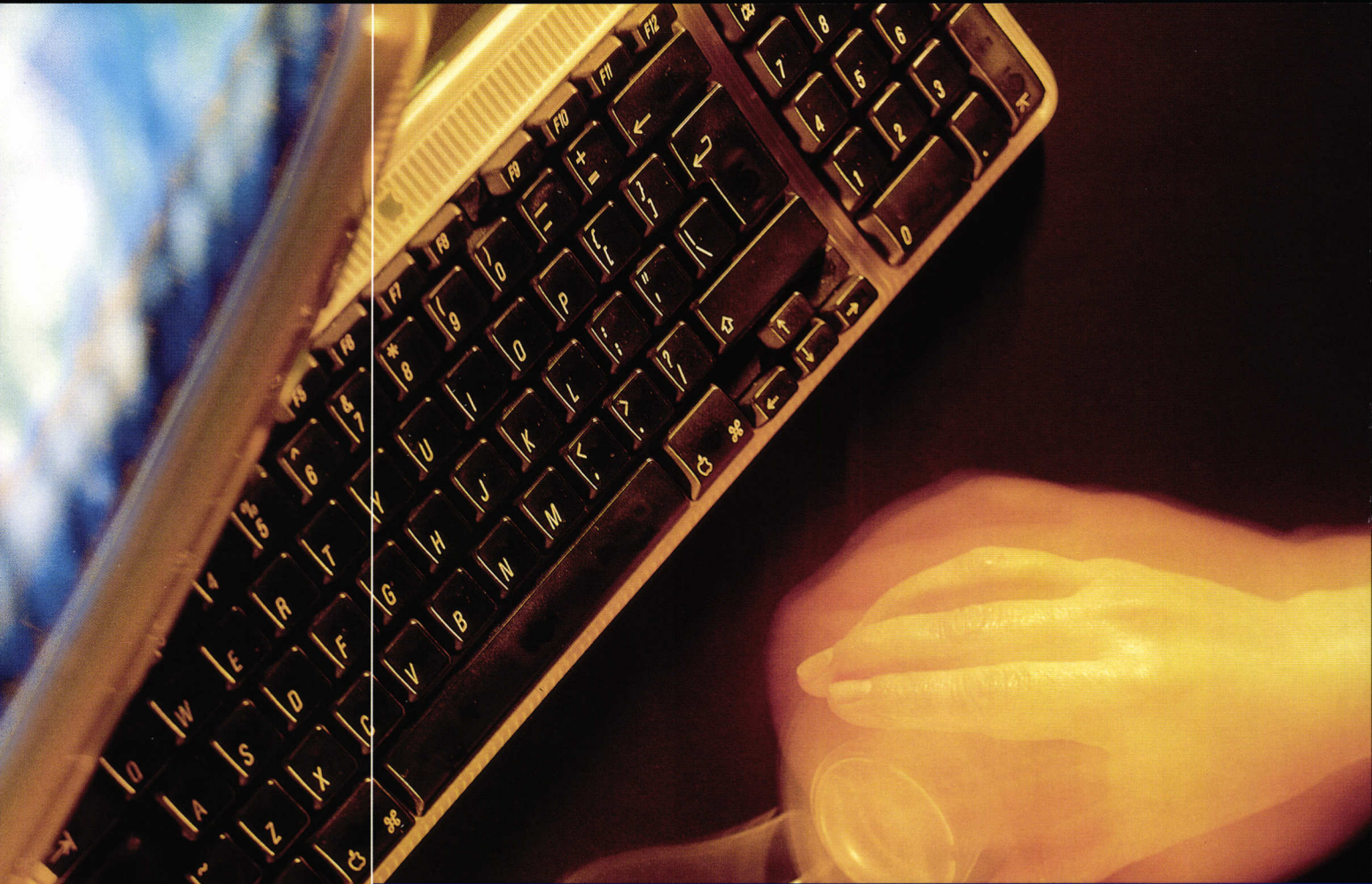


The feasibility of measuring the universe in half-atoms

SCIAMACHY has not yet been launched, but the development of the next generation of satellites for the European Space Organisation, ESA, is already in full swing. The launch of GAIA is expected to take place before 2009. This satellite will measure the speed and position of a billion stars with extremely high precision, the ultimate goal being to understand the structure and history of our galaxy. These measurements are also needed for determining the position of telecommunication and GPS satellites that read their position in relation to the earth from the position of the stars.

A key satellite subsystem is an onboard laser metrology system capable of measuring angular variations with the required accuracy, by measuring displacements as small as 50 picometers. Matra Marconi Space France (MMS-F) asked TNO to ascertain whether the accuracy required was attainable given the design principle of the measuring instrument. It took only ten months to design and build a simulation of the metrology system. Tests were carried out with MMS-F at TNO to ascertain the feasibility of the principle and the desired accuracy. For ESA, the concrete proof that it is possible to measure distances to within an accuracy of 50 picometers has removed a significant question mark regarding the feasibility of the project as a whole.

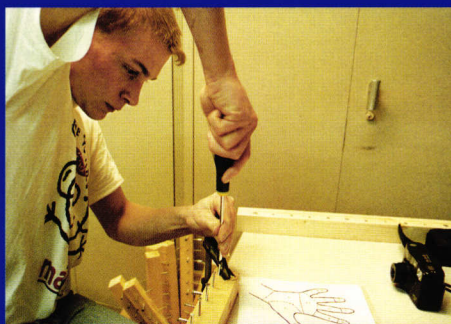




Using knowledge, technology and ergonomics to combat RSI

One in three people in the Netherlands suffers from it, according to the latest TNO figures. Repetitive movements, applying force and an inappropriate posture at work can all cause disorders that can persist for at least a year. The generic name for these complaints is Repetitive Strain Injury (RSI). An explanation for its cause is still hypothetical, but irritation caused by physical overload and inadequate recovery time play a large role.

TNO has been looking into this disorder for years, with researchers carrying out epidemiological studies that contribute to scientific knowledge and providing solutions to practical problems. The solution lies in designing ergonomically sound industrial workstations, tools and cabins. Drastic measures, such as mechanisation or switching to an entirely new way of working, are sometimes needed. Solutions have been found for problems related to VDU (Video Display Unit) work such as the application of speech recognition and advanced combinations of eye tracking, voice response and touch screens. A small example reveals the impact of ergonomically correct design: for Bahco tools, TNO tested an



ergonomically designed screwdriver. It appeared that 34 percent more force could be generated with it, while productivity increased by 8 percent compared to another professional screwdriver. Discomfort – a health indicator – declined by 15 percent, as did the number of blisters and incorrectly driven screws.



Dynamic flow expertise allows prompt and safe operation

Problem: A new factory at a refinery in Southern Europe allows the chemical waste generated in its refining process to be converted into electricity and other useful products. The process conditions in this advanced installation are unique. Unfortunately, the vibrations in a small section of the pipe system turn out to be unacceptably large. The problem relates to pumping propane, one of the installation's products. The refinery does not want to purchase the installation from the engineering firm until the problem is fixed. The importance of transferring the technology quickly is great: each day production is shut down costs some half a million euros so time is of the essence. The pump supplier, another party involved, is also trying to solve the problem, but to no avail.



Solution: TNO specialists in the field of dynamic processes in pumps, compressors and pipe systems carried out pressure pulsation measurements in addition to vibration measurements. They encountered a few surprises: propane proved to behave differently under the pressures and temperatures of this process than it does in other processes. That's why large pressure pulses occurred in the pipe system. To find the cause, the TNO experts used the measurement results and the PULSIM calculation model. Proposals for improvements that resulted could be implemented quickly. Their pump modification recommendations proved to have the desired effect: the installation was subjected to a test that went off without a hitch and it could therefore be put into use both safely and in time.



Mild preservation for improved taste and a long shelf life

Adequate preservation of food products often reduces product quality. The preservation technique most often applied to render microorganisms harmless to humans is heat, but this affects product properties such as taste, nutritional value and flavour. For these reasons, TNO investigates alternative ways to preserve foods, ways which are less invasive to product quality, yet provide the same level of protection as conventional techniques. However, the expense of innovative preservation methods must be justified by considerable improvements in safety or quality.

A number of methods seem to meet these demanding requirements. Pulsed Electric Fields appear to be promising for products such as fresh-like fruit juices. The technique is best suited for liquid products and uses ultra-short pulses with potential differences ranging from 10,000 to 40,000 Volts per centimetre. Ready-to-eat meals, solid products and liquids can be preserved using the Ultra High Pressure technique that applies pressures up to 10,000 atmospheres. The application of High Intensity Pulsed Light to preserve bread, eggs, vegetables, fruit or packaging materials, for instance, is a method derived from findings in the Star Wars programme. A very short exposure of 20,000 times the intensity of incidental sunlight on Earth leads to a significant reduction in the number of microorganisms. Laboratory experiments and pilot plant tests have produced a number of promising results. TNO is therefore developing these promising techniques to encompass preservation in food and food related industries.



Video systems provide a better view of refuelling in the air

The Royal Dutch Air Force has two KDC-10 tanker/transport aircraft that are used to refuel fighter aircraft and bombers in flight. This is done with a remote-controlled telescopic arm, the so-called boom. The operator sits at the front of the aircraft just behind the cockpit, at the Remote Aerial Refuelling Operator (RARO) workstation. He watches the telescopic arm's movement on a screen and controls it using joysticks and pushbuttons. For these observations, the operator uses detailed stereoscopic video images from cameras located under the aircraft.

The air force is striving to get the best possible image quality. Because the current system does not satisfy the requirements, TNO has developed a method for measuring image quality objectively. In consultation with the manufacturer, a programme was developed for systematic testing of the RARO video circuits. The goal is to identify any potential weak system components. Both the properties of the cable connection between the video cameras and the RARO workstations as well as the frequency and amplitude behaviour of the components used were subjected to a critical examination. The conclusions derived from these measurements will be used to gradually improve the RARO video system in the coming years.



TNO in figures

Consolidated balance sheet as at 31 December 1999

After appropriation of result (in thousands of euros)

	31-12-1999		31-12-1998	
Fixed assets				
Intangible fixed assets		81		196
Tangible fixed assets		212,151		188,175
Financial fixed assets		7,536		8,787
		219,768		197,158
Current assets				
Stocks and work in progress	24,563		13,138	
Accounts receivable	97,279		79,416	
Securities	52,321		51,729	
Cash	- 30,998		17,108	
	143,165		161,391	
Current liabilities	- 121,998		- 108,669	
Operating capital		21,167		52,722
Total		240,935		249,880
Financed as follows:				
Equity				
– General reserves	202,364		202,696	
– Appropriated reserves	4,506		–	
		206,870		202,696
Investment funds equalisation account		8,760		9,765
Third-party interests		34		- 9
Provisions		22,416		36,382
Long-term debts		2,855		1,046
Total		240,935		249,880

Consolidated profit and loss account 1999

(in thousands of euros)

	1999	1998
Turnover	440,397	403,476
Other operating income	28,207	14,597
Operating income	468,604	418,073
Personnel costs *)	- 264,187	- 232,246
Direct project costs	- 69,800	- 69,229
Other operating costs	- 92,649	- 82,787
Depreciation intangible fixed assets	- 51	- 156
Depreciation tangible fixed assets	- 32,314	- 30,164
Contributions issued	- 535	- 4,109
Operating costs	- 459,536	- 418,691
Operating result	9,068	- 618
Income from financial fixed assets	1,463	- 485
Income from securities	- 4,164	6,993
Interest received	1,228	1,338
Interest paid	- 1,437	- 225
Result from ordinary operations before taxation	6,158	7,003
Taxation	- 305	- 173
Result from ordinary operations after taxation	5,853	6,830
Third-party interests	- 10	10
Result	5,843	6,840
Appropriation of result:		
Result	5,843	6,840
Addition to:		
– appropriated reserves for operating risks	- 2,237	–
– appropriated reserves for knowledge investments	- 2,269	–
Result after movements in the appropriated reserves	1,337	6,840
Additions to general reserves	- 1,337	- 6,840
	–	–

*) – including personnel profit sharing to the amount of € 1.914 (introduced in 1999).

Credits

Production	TNO Corporate Communication
Text and copy	CPLS, Eindhoven
Graphic design	Barlock, The Hague
Print and lithography	Drukkerij Lakerveld, The Hague
Photography	
Eric de Vries, The Hague	
Witho Worms, Almere	<i>pages 6 and 7</i>
Corné Bastiaansen, Amsterdam	<i>pages 16 and 17</i>
Hollandse Hoogte, Amsterdam	<i>page 21 left</i>
Benelux Press, The Hague	<i>pages 23 top and 30 left</i>
ANP, The Hague	<i>pages 24 right, 27 top and 40 left</i>
Hans Oostrum, The Hague	<i>pages 25 top, 31 right and 42 left</i>
Aveq, The Hague	<i>page 27 right</i>
Transworld, Amsterdam	<i>page 32 right</i>
Dolfinarium Harderwijk	<i>page 39 left and top</i>
Tony Stone Images, Amsterdam	<i>cover and page 37 top</i>
Philips Research, Eindhoven	<i>page 38 top</i>
ESA, Noordwijk	<i>page 43 left</i>
Digital Stock	<i>page 46 left</i>
Fotovlucht, Soesterberg	<i>page 47 left</i>

© TNO, April 2000

ISBN 90 6743 664 X

ISSN 1383 360X

Making technology work

TNO Business Information Desk is your central point of access to TNO's knowledge and expertise.

It links business and institutions with TNO institutes, acting as a guide for those wishing to know more, and putting you in touch with the right TNO specialists for your specific technological questions.

For further information

TNO Business Information Desk

T +31 15 269 69 69

F +31 15 261 24 03

infodesk@tno.nl

www.tno.nl

