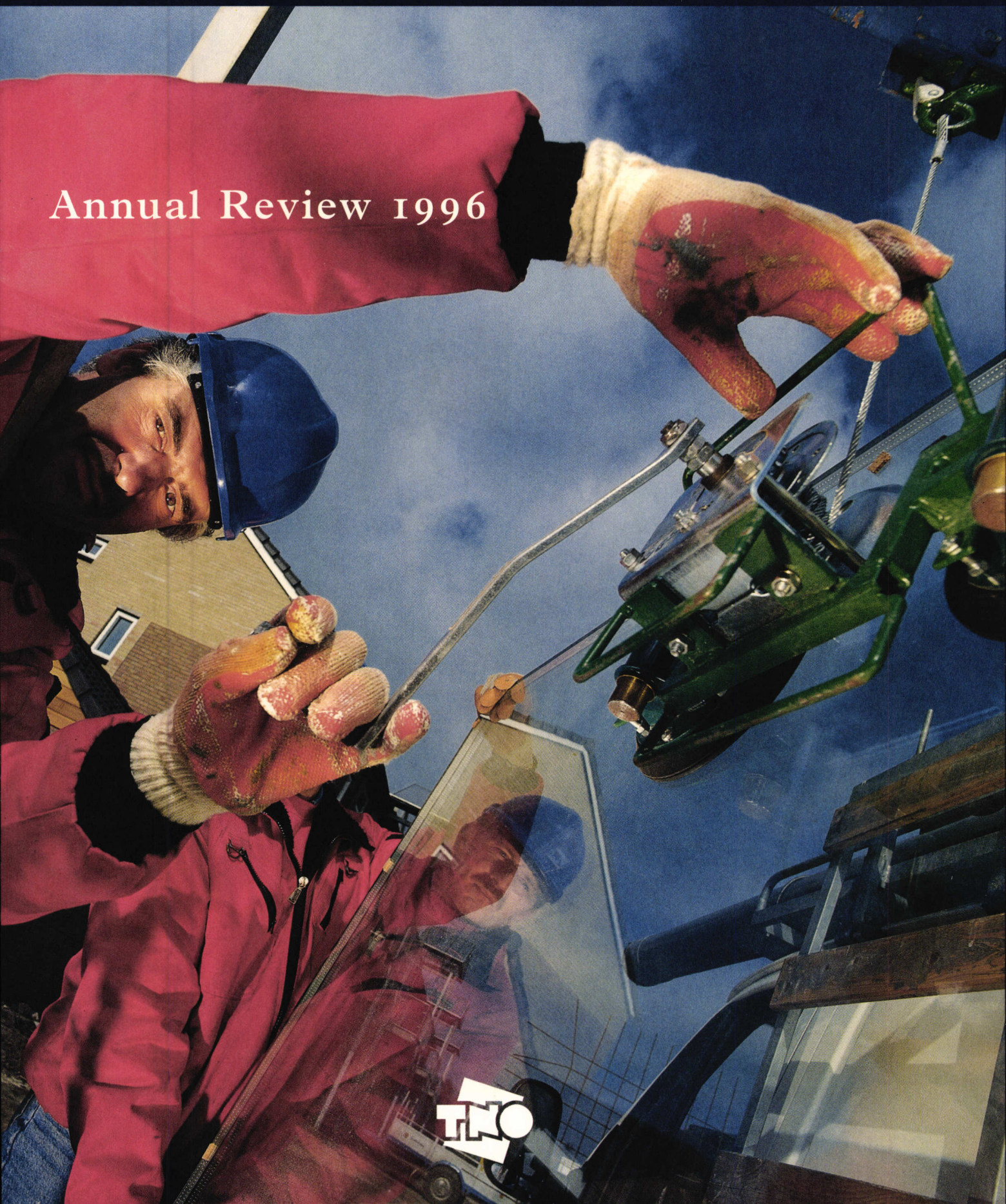
Netherlands
Organization for
Applied Scientific
Research (TNO)

Annual Review 1996



TNO today

There are 4,000 people at TNO, professionals who together form a leading independent contract research organization. An organization whose expertise and research make a substantial contribution to the competitiveness of businesses and organizations, to the economy and to the quality of our society as a whole. The unique position TNO holds is due to its versatility and its capacity to integrate this knowledge and expertise.

As a large contract research organization TNO provides a link within the innovation chain between fundamental research as a source of knowledge and practical application as the use of knowledge which can be commercially exploited.

TNO is committed to being an organization whose quality, creativity, accessibility and entrepreneurship enable its products to be available to a broad range of businesses as well as to organizations and governments.

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Contents

Supervisory Board
(composition as at 1 April 1997)

Prof. R.F.M. Lubbers, M.Sc., chairman
Prof. M.J. Cohen, LL.M.
Prof. Dr. P.M.E.M. van der Grinten
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Prof. Dr. A.W. Veenman
R.J. de Wijkerslooth de Weerdesteyn, M.Sc.

Mw. D.E. van Welsen-Moonen, secretary

Board of Management
(composition as at 1 April 1997)

J.A. Dekker, M.Sc., president
F.Th. Gubbi, M.Sc., vice-president
Dr. P. Folstar
E.I.L.D.G. Margherita, M.Sc.

Mrs. D.E. van Welsen-Moonen, secretary

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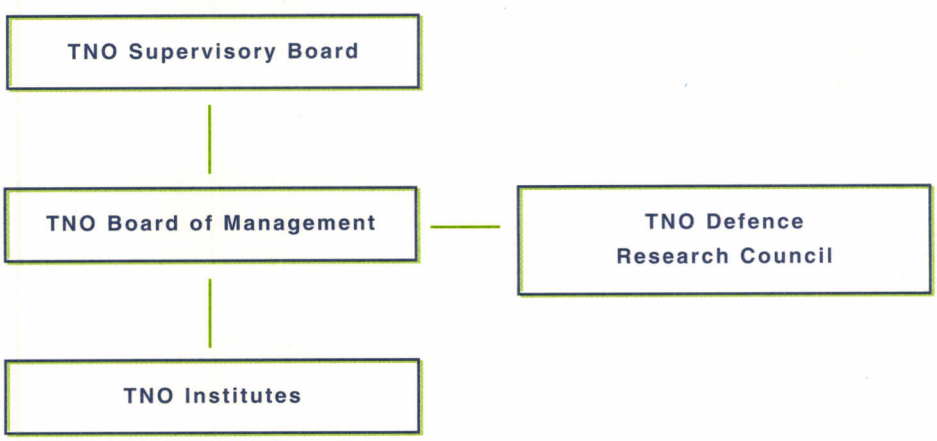
↑ TNO Board of Management
From left to right:
E.I.L.D.G. Margherita
P. Folstar
J.A. Dekker
F.Th. Gubbi

Organizational structure TNO



Introduction

Dear reader,
Competitive power in business and levels of prosperity are increasingly determined by our ability to apply new knowledge in products, processes and services. In 1996, TNO once again did their best to support their clients in doing just this. The quality of our 'product' and our clients' satisfaction are a top priority.

During the year under review, we continued to work hard building strategically important partnerships. This is not only in the interest of TNO but also in the interest of the Dutch knowledge infrastructure. We have chosen to play an active role in such developments. Our relationships with universities, major technological institutes and large R&D driven companies have been further intensified and expanded. Support for the small and medium-sized enterprises also remains a high priority.

TNO is progressing smoothly as it follows its 'Strategy 2000' plan drawn up in 1994. Following a slimming and restructuring period, there is now room for growth and new initiatives. For the first time in years, there has been a modest increase in staff numbers. This turnaround is expected to be reflected in turnover growth in the coming years.

At NLG 728 million, turnover was slightly down on 1995 (NLG 743 million). The result of NLG 11 million was a little up on 1995. The turnover from contract research totalled NLG 440 million in 1996 (1995: NLG 444 million). Of that total, NLG 105 million can be attributed to foreign customers, NLG 223 million to Dutch industry and NLG 112 million to the Dutch government. The turnover from foreign contract research made up almost a quarter of the total turnover from contract research. This portion of the turnover has remained proportionately steady over the last three years.

Through TNO Management BV, a TNO subsidiary, we are unfolding various commercial activities. Within the knowledge-based organization that TNO is, these activities have become an indispensable instrument for making new knowledge profitable in special cases.

It is TNO's policy to fortify our links with trade and industry all over the world. Internationalization policy in 1996 was aimed at both extending existing activities and laying the foundation for new ones. We managed to consolidate our market position in Japan, primarily due to the success of TNO Road-Vehicles Research Institute.
In Prague we opened a representative office to enhance our Central and Eastern European market position. This has already led to a definite increase in turnover from international donor-financed projects.
Support centres were opened in Detroit and Kharkov (Ukraine) to offer specific assistance in those market regions. For 1997, new facilities are scheduled in the United States, Southeast Asia and Western Europe.

Collaboration with universities is essential to extending the development of our knowledge. Our policy aims to strengthen ties with the universities, partly through joint ventures. In 1996, six of these structural partnerships were operational. In 1997, new fields in need of such stimulation will be explored. TNO is working together with business and R&D-organizations to establish 'top institutes' in four areas: food, polymers, metals and telematics. In our view, these top institutes can provide an important impetus towards promoting partnership between companies and research institutes in the area of technological innovation in the Netherlands. Moreover, TNO is participating in almost all of the sub-programmes of the European Union's Fourth Framework Programme.

A world dominated by those capable of effectively and efficiently translating new knowledge into products and services is one full of opportunity for an organization like TNO. Our challenge is to capitalize on those chances. We therefore foresee a growth in turnover, results and staff and view the developments for TNO with confidence in 1997.

Jan A. Dekker
President of the TNO Board of Management

Key figures

In millions of Dutch guilders
(unless stated otherwise)

	1996	1995	1994
Result			
Result TNO	11.4	10.3	5.5
Result institutes	17.0	19.3	24.3
Result institutes as % of turnover contract research institutes	3.9 %	4.4 %	5.5 %
Depreciation of tangible fixed assets	71.1	86.0	87.8
Other means of investments	14.7	7.9	7.5
Cash flow	97.2	104.2	100.8
Income			
Turnover	728.0	743.4	745.1
Capital expenditure			
Capital expenditure in buildings and fixed technical installations	18.6	15.9	14.2
Capital expenditure in equipment	40.5	40.8	37.7
Capital expenditure in tangible fixed assets as % of turnover	8.1 %	7.6 %	7.0 %
Personnel			
Average number of empoyees	4,000	4,200	4,500
Personnel costs	350.3	359.5	378.6

Balance sheet as at 31 December 1996

after location of result

(in thousands of Dutch guilders)

		31-12-1996		31-12-1995
Fixed assets				
Intangible fixed assets		-		33
Tangible fixed assets		347,632		375,121
Financial fixed assets		162,040		75,317
		509,672		450,471
Current assets				
Stocks and work in progress	24,889		21,704	
Accounts receivable	132,119		123,876	
Cash	54,111		118,799	
	211,119		264,379	
Current liabilities	- 158,793		- 154,815	
Operating capital		52,326		109,564
Total		561,998		560,035

Financed as follows:

Equity	423,159	411,716
Investment funds equalization account	19,680	20,420
Provisions	118,762	126,933
Long-term debts	397	966
Total	561,998	560,035

Profit and loss account 1996

(in thousands of Dutch guilders)		1996		1995
Turnover		727,962		743,384
Other operating income		37,236		35,655
Operating income		765,198		779,039
Personnel costs	447,001		433,825	
Direct project costs	113,202		127,112	
Other operating costs	128,754		126,435	
Depreciation of intangible fixed assets	33		33	
Depreciation of tangible fixed assets	71,147		86,049	
Contributions issued	4,836		5,759	
Operating costs		- 764,973		- 779,213
Operating result		225		- 174
Income from financial fixed assets		8,459		5,272
Interest received		3,305		5,641
Interest paid		- 546		- 438
Operating result		11,443		10,301

Ins & outs

TNO's mission is to strengthen the competitiveness of trade and industry and to support governments in policy formulation and implementation.

In this mission knowledge is the key factor. Translating this knowledge into practical applications is the chief activity of TNO. We acquire knowledge by producing or purchasing it. Knowledge that we process and combine and, where necessary, enhance with knowledge generated by our own research. We do this for customers in the private and public sectors all over the world. TNO's output is multifarious, from quality control of consumer products to producing complete instrumentation needed for satellite analysis of the atmosphere's composition. Our knowledge results in new or improved products. We specialize in processes, functional materials, production techniques, analysis and consultation. In addition, we transfer our knowledge through training and education, publications and demonstration projects.

Knowledge portfolio

TNO's operational knowledge comprises more than 400 key technologies. These make up our strategic technology portfolio, and are grouped under the following categories:

- *Production*
- *Materials*
- *Environmental and process technologies*
- *Telematics and information*
- *Electro-engineering and physical systems*
- *Biotechnology*
- *Food*
- *Health*
- *Automotive and infrastructure*
- *Energy*
- *Building*
- *Applied geoscience*
- *Technology and policy studies*
- *Defence*

The individual knowledge of our staff acquires added value by being part of the knowledge network in which the thirteen TNO institutes operate. In this network, we strive for synergy and we explore the possibilities generated by combining knowledge from various fields. This puts TNO in a strong position, especially in those segments of the contract research market characterized by complex issues. At the end of 1995, 138 TNO inventions had been protected under one or more patents. In 1996, another 28 inventions were added to the list. Patents expired on 20 of the inventions, so that at year end 1996, TNO owned 146 protected findings.

Knowledge input

In the long term, if we want to continue to provide the services demanded by the market, we must continue to invest in new knowledge. TNO is therefore continually involved in projects which explore new opportunities for application, opening up new fields of activity, and becoming more proficient in novel technologies. We are in a position to do this partly thanks to the result originating from our contract research. But more importantly, the government furnishes us the necessary financial resources in the form of basic financing and programme-related financing (see Figure 2, page 11). A very brief selection of some predominantly government- funded projects completed in 1996 is given below.

TNO Institute of Industrial Technology

- *Antifouling coating based on fibre deposition on metal*
- *Application of electrically active polymers in sensors, LEDs, etc.*
- *Welding of metal-matrix composites*

TNO Institute of Applied Physics

- *Calibration facility for aerospace instrumentation*
- *Ceramic/plastic composites (scratch resistant plastic)*

TNO Road-Vehicles Research Institute

- *New crash dummy for whiplash studies*
- *Sensors for use in `smart vehicle' concept*

TNO Building and Construction Research

- *Expert system for damage analysis of historic brickwork*
- *Prolonging the lifetime of residential stock*

TNO Nutrition and Food Research Institute

- *Method to determine the total anti-oxidant effect of food*

- *Anti-microbial effect of milk peptides and reduction of diarrhoea in calves*

TNO Institute of Environmental Sciences, Energy Research and Process Innovation

- *Anorexia toxica (in water fleas) as an indication of polluted surface water*
- *Recovery of almost pure lead from waste (Lerefleos)*

TNO Prins Maurits Laboratory

- *Identification of toxins used in biological weapons*
- *Fast dischargeable, bipolar lead-sulphur battery*

An important part of knowledge input is related to the inflow of new staff. Of the 390 appointed in 1996, 260 were academics and 61 had a higher vocational training background. By the end of 1996, TNO employed 1,846 academics and 852 higher vocational training graduates. In other words, of the total TNO workforce, almost 50 percent is made up of academics and more than 20 percent of higher vocational training graduates.

TNO and the universities

TNO's mission implies an essential link between the universities and the market/society. Partnerships with universities are vital to TNO's knowledge input. This relationship with the academic world manifests itself in various ways. The structural, permanent joint ventures between TNO and universities, which involve equal input from the respective university and TNO, are important platforms for collaboration. The primary objective of these joint ventures is to foster the transfer of high-quality university research into market applications. The six existing joint ventures are summarized in Table 1. Preparations are underway for thirteen new joint ventures. Our ties to the universities are close in terms of staff as well (see Figure 1). In 1996, 46 TNO employees were part-time professors, with 15 of those professorships financed through a special fund established by TNO (year-end 1996). An annual sum of NLG 3 million is earmarked for financing post-graduate programmes.

Figure 1
Staff relationship between TNO and universities

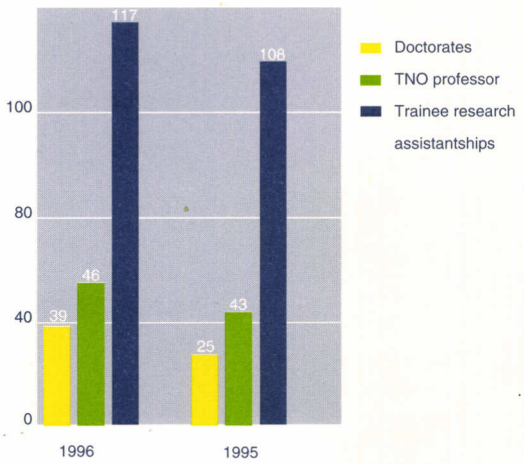


Table1
Permanent joint ventures between TNO and universities

Joint venture	University
TNO-RUL Centre for Phytotechnology➔	*University of Leiden*
TNO Centre for Protein Technology➔	*Agricultural University of Wageningen*
Centre for Veterinary Health and Environmental Hygiene➔	*University of Utrecht*
TNO Centre for Soil Management and Remediation Technologies➔	*Agricultural University of Wageningen*
TNO-TUE Centre for Building Research➔	*Technical University of Eindhoven*
TNO-TUD Centre for lightweight structures ➔	*Technical University of Delft*

Cluster projects

Other important mechanisms for acquiring knowledge at TNO are cluster projects and projects performed as part of the European research programmes.

Cluster projects are strategic research and development projects in which high-tech companies and research institutes collaborate. These projects are partly funded by the Dutch Ministry of Economic Affairs. The policy of working together with R&D driven companies to realize strategic, large-scale projects has been successful. From 1993 to 1995, TNO was involved in 12 of the 14 projects remunerated by the Ministry of Economic Affairs. During 1996, TNO was engaged in 13 of these cluster projects, and three more started up at the end of the year. The separate financing arrangement originally created by the Ministry of Economic Affairs for these projects has now been terminated. In the future, financial support for the cluster projects will come from the Ministry of Economic Affairs' programme-related financing.

Cluster Projects started in 1994/1995

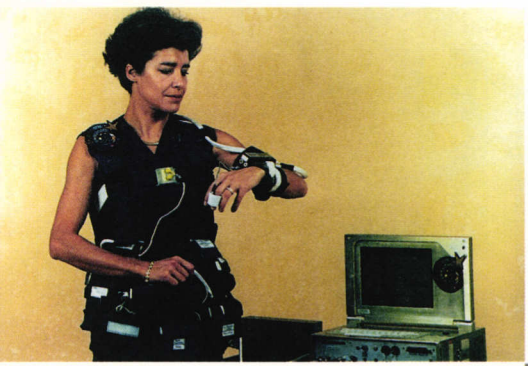
- *separation technology/thin layers*
- *processing technology/meat processing*
- *production technology/thermoplastics*
- *information technology/computer architecture*
- *functional materials/glass and ceramics*
- *food technology/wheat chain*
- *information technology/process control*
- *surface technology/coatings*
- *functional materials/crash safety*
- *production technology/rapid prototyping*
- *information technology/simulator development*

Cluster Projects started in 1996

- *process technology/cement production*
- *information technology/revalidation*
- *information technology/inspection*
- *production technology/applied physics*
- *production technology/mechatronics*

In cluster projects, TNO not only collaborates with large companies like Stork, Holec, Unilever and Hoogovens. We are also working together with the Technical University of Delft (Faculty of Chemistry and Materials Science) on a project for the casting industry. This 'Lost Foam' project is coordinated by Lovink-Terborg BV. Other partners involved in the project are Gemco Lost-Foam, Gemco Engineers and De Globe BV. The idea is to embed a plastic foam model in sand. When poured in, molten iron causes the foam to evaporate and fills out its shape. With this new method, complex products can be cast with a new freedom of design and with extreme precision.

European research programmes are also vital to knowledge build-up at TNO. The European research programmes in which TNO participates include the EU Fourth Framework Programme, EUREKA and EUCLID (EUREKA's defence counterpart), as well as PHARE and TACIS. This last project was specially initiated to offer support to Central and Eastern Europe.



↑ French astronaut with a portable blood-pressure meter, the Portapres, developed by TNO.

→ One of the cluster projects aims to improve the quality in the chain of wheat - from grain to baked product.

Output

A breakdown of the turnover percentages at TNO is provided in Figure 2. Not only is knowledge an important resource at TNO, it is also our major product. A principal portion of our knowledge is generated in contract research. Figure 3 and Table 2 provide a more detailed impression of the magnitude of this share of our output and the related market sectors. Figure 3 gives a global breakdown of the contract research turnover, while Table 2, page 12 shows a breakdown by ministry.

In our 'Strategy 2000' document we formulated guidelines for classifying markets of TNO. Next year, these guidelines will be used for arranging TNO output according to clusters of economic activity that are important for the Netherlands. As we are currently in a transitional phase in terms of the financial reporting, we shall confine ourselves to a qualitative summary.

The domestic market turnover showed relatively sharp growth (more than 10 percent) in the market clusters Multimedia and Telecommunications (19 percent), Commercial Services (13 percent) and Chemistry (12 percent). The Manufacturing Industry and Health cluster remained more or less at the same level. For TNO turnover, the most important clusters are those of Commercial Services and Manufacturing Industry (including the metal-electrical technology industry together with the plastics processing industry and a few smaller sectors, like textiles, clothing, furniture, glass, ceramics, paper and cardboard). The Commercial Services cluster has shown steady turnover growth in the last few years, and the Manufacturing Industry cluster has slightly stagnated, partly due to the recession in the machines and equipment sector.

In the foreign market, turnover in terms of volume was dominated by the EU countries, International Organizations (e.g. EU, World Bank, UN), Japan and Northern America. Roughly speaking, neither the current 14 percent growth in the Japanese market nor the 4 percent growth in the turnover generated from International Organizations could compensate for the decline experienced in other sectors. Our policy was accordingly modified in 1996 to reverse the downturn in turnover from the EU countries and Northern America and to realize extra turnover growth in Japan, Central and Eastern Europe, Southeast Asia as well as from projects for International Organizations.

In 1996, preparations were finalized for a prestigious joint project with the German Fraunhofer Gesellschaft. The aim of the project is to strengthen the link between science and technology in Russia and the country's market economy. A specific policy in these fields will be developed for four regions. In

Figure 2
Breakdown of 1996 turnover for TNO

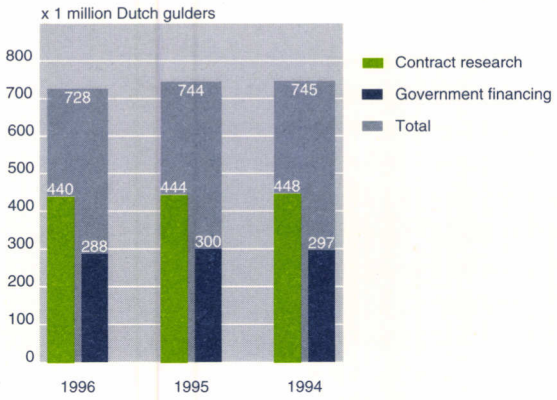


Figure 3
Contractresearch turnover

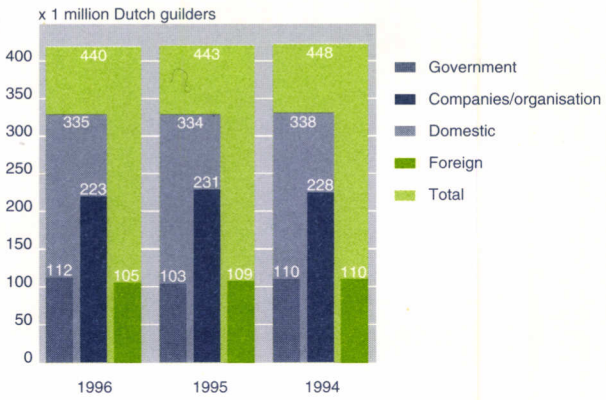
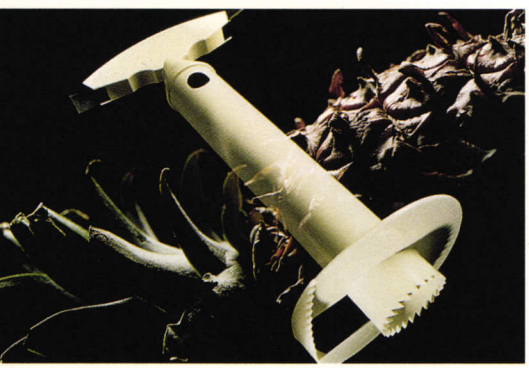


Table 2

Turnover from Government Contract Research (in millions of Dutch guilders)

	1996	*1995*	*1994*
General Affairs/Justice/ Home Affairs/Finance	*1.9*	*0.6*	*2.4*
Foreign Affairs	*3.5*	*4.8*	*6.1*
Education, Culture and Science	*0.7*	*1.4*	*0.9*
Defence	*51.2*	*40.7*	*31.2*
Housing, Spatial Planning and Environment	*13.3*	*15.2*	*19.1*
Transport, Public Works and Water Management	*16.1*	*16.0*	*18.3*
Economic Affairs	*7.0*	*7.2*	*13.3*
Agriculture, Nature Management and Fisheries	*1.1*	*1.3*	*1.3*
Social Affairs and Employment	*2.5*	*3.1*	*3.8*
Health, Welfare and Sport	*4.2*	*3.3*	*4.3*
Local authorities	*9.9*	*9.5*	*9.2*
Total	***111.4***	***103.1***	***109.9***



A pineapple slicer cutter is an example of a succesfull product development. The product has found its way all over the world on a large scale.

addition, the project aims to help the Russian research organizations improve their market orientation.

Business centres

Special TNO Business Centres have been established to serve markets whose needs cross the boundaries of individual institutes. In 1996, TNO Pharma (see also page 34) joined the existing centres - TNO Centre for Soil and Sediment Remediation Research, TNO Multimedia and Telecommunications and TNO Centre for Ageing Research. Other centres to be set up before long are TNO Centre for Crime and Fraud Prevention and Security, and TNO Centre for Traffic and Transport.

Optimum knowledge yield

Knowledge developed by TNO is only profitable when it serves a market with purchasing power or meets a social objective. Three stages can be distinguished in the course of developing knowledge: the fundamental stage, the applications-oriented stage and the commercial stage. The government affords TNO the means to bridge the first two stages. The market needs to fund the third one. Sometimes it is not possible to find a company that wants or can afford the cost of commercializing a TNO finding. Companies may lack the required expertise or deem the risk too great. If in such cases TNO does not proceed itself with the third stage, there is a chance that the finding will be lost. In some cases, TNO therefore assumes the responsibility for producing and commercializing a product. This happens predominantly for specialized software packages which have been developed for use at TNO and are continually upgraded. Some examples are: MADYMO, Vehicle Dynamics Database, Delft Tyre

Software, Effects, KnoWind, CYCLE, BERTIX, TNO Stereotest, Sofia software, and TOMO software.

Generally, TNO may find an application for its knowledge in three ways. A company that is prepared to determine the market value of the knowledge can license it. If that does not work, TNO tries to find a company with whom to jointly undertake further development, and thus share the risk. In the second case, TNO withdraws from participation as soon as the company is capable of proceeding independently. If the second option does not work either, TNO may decide to further develop the finding itself under a separate, independent organizational form. TNO has established TNO Management BV (TMB) for this purpose and owns 100 percent of its shares. TMB functions as a holding company for a number of spin-off companies. As of 1 April 1997, there were ten majority interest participations and nine minority interest participations.

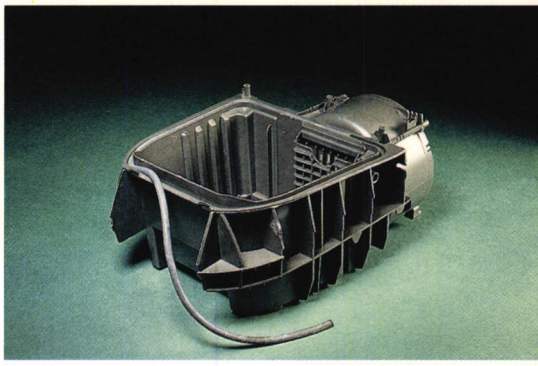
Consultancy and knowledge transfer

A substantial proportion of TNO's output is consultancy. One noteworthy project is the 'SME Initiative' that targets small and medium-sized enterprises (SMEs) wishing to take strategic steps towards new, more competitive technology and market positions. Professional consultants guide individual companies along an advisory trajectory. Their goal is to achieve a strategic plan centred around both utilizing new knowledge and ensuring future markets for the company's products. Improving efficiency is also incorporated in the strategic plan. Following a trial period, projects had started at 30 companies by the end of 1996. One of the beneficial side effects is that the contacts established help promote knowledge transfer from TNO to the SME. An initial evaluation of the initiative showed positive results.

TNO's knowledge products are presented worldwide at trade fairs and exhibitions. Some of the trade fairs in which we participated during the year were:

- *SmartCard `96 (London)*
- *Hydro `96 (Rotterdam)*
- *Power Gen (New Delhi)*
- *Glas Tec `96 (Düsseldorf)*
- *Support `96 (Utrecht)*
- *RAI Building Fair (Amsterdam)*
- *Hannover Messe (Hannover)*
- *Aquatech (Amsterdam)*
- *IKK96 (Nürnberg)*
- *Energy Economy `96 (Amsterdam)*
- *Holland Oil & Gas (Amsterdam)*
- *Eusar `96 (Königswinter)*
- *ITEC `96 (The Hague)*
- *Eurosatory `96 (Paris)*
- *InterAuto `96 (Amsterdam)*
- *Telematica (Amsterdam)*

↓ Rapid Prototyping is an indispensable aid in new product development. The photograph shows a vacuum cleaner housing.



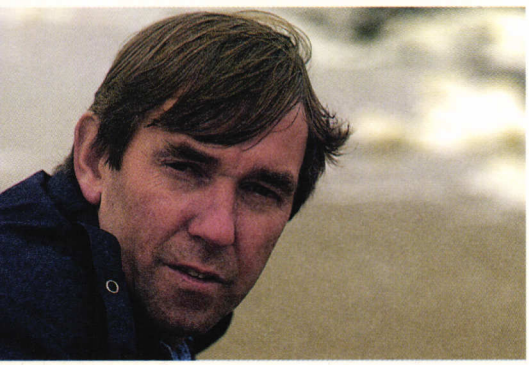
A substantial amount of TNO's knowledge was disseminated in the form of reports and publications. In 1996, TNO published approximately 5,500 research reports and 6,000 'inspection reports'. TNO staff were also authors of 1,400 publications including 39 dissertations.

Senior Research Fellows

TNO confers on those researchers with an exceptional history of service its 'Senior Research Fellow'. In 1996, four TNO staff were awarded this recognition.

Air - sea exchange

Dr. Gerrit de Leeuw (1949) has worked since 1980 at the TNO Physics and Electronics Laboratory, one of TNO's three defence research institutes. Gerrit de Leeuw studies the exchange of gases and aerosols between the ocean and the atmosphere. Or to be more specific, the influence hereof on the propagation of electromagnetic radiation in the atmosphere. De Leeuw is primarily interested in the processes at work on the interface between air and water, where the breaking waves create a permanent presence of salty droplets. The small salt-laden droplets, usually known as aerosols, hang in the air for shorter or longer periods of time: large

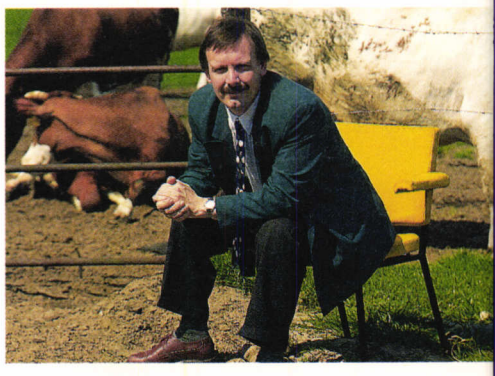


↑ Dr. Gerrit de Leeuw

ones stay for a few minutes, very small ones can remain airborn for days. The research team is trying to come up with a model to describe and predict the view over the sea. How far can a laser beam reach? How much will scattering and absorption weaken the beam? What distance can an infra-red camera span? An important factor in all these questions is the size distribution of the aerosols. This field of research has assumed a broader relevance in recent years as part of the discussion over climate changes. The interaction between the atmosphere and the ocean plays a crucial role in this, and collaborative projects have been set up with environmental researchers and meteorologists. It is a generally accepted fact that aerosols greatly influence the climate. Other important issues are the effects of the ocean in regulating the climate by air-sea exchanges of greenhouse gases.

Extraordinary powers of discernment

Jan van der Greef (1952) is Managing Director of TNO Pharma and part-time professor at the University of Leiden. He joined TNO in 1980 and since then has made a name for himself with his research in the field of chemical analysis techniques based on mass spectrometry. A major category, mass spectrometers utilize the fact that the orbital curvature of an electrically charged particle (ion) in a magnetic field depends on the mass to charge ratio of the particle. This method only works if one is able to evaporate the sample into volatile constituents and ionize it. Jan van der Greef has broken new ground in the field of analyzing samples that cannot be evaporated without suffering degradation. His team was among the the first in the world to couple mass spectrometry with high-performance liquid chromatography to separate non-volatile mixtures. Another success was the introduction of new types of ion sources that are capable of ionizing non-volatile compounds - initially by field ionization, later by plasma desorption and laser desorption. This relatively fundamental work has since acquired numerous applications. For instance, it is a way for TNO to monitor growth hormones in Dutch veal. And the pharmaceutical industry is highly interested in the microscopic precision of the laser desorption technique which, for example, can be used to study the biochemistry in individual cells.



↑ Prof. Dr. Jan van der Greef

Preventing traffic injuries

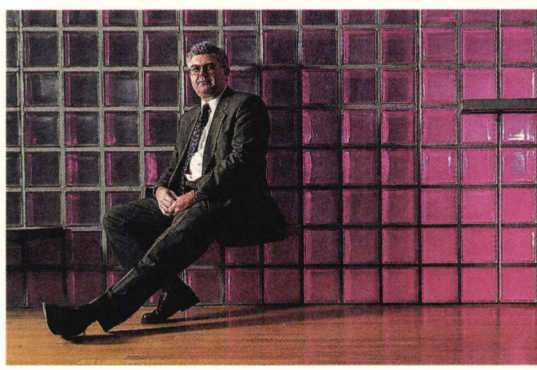
One plane crash a day with 150 casualties. That is what the average number of traffic deaths per day in Europe is comparable to. It is against such a sad background that the work of Jac Wismans (1948) has gained prominence. He has worked at the TNO Road-Vehicles Research Institute since 1978 on crash safety.

The Crash Safety Research department studies the effects of impacts on vehicles. It concentrates on developing advanced crash test dummies, mathematical simulations and road safety, and finding applications for these developments. The integration of mathematical simulation and full-scale crash models produces particularly interesting results. This, taken with TNO's independent status, has given the department special status. Almost all major car manufacturers use the technology developed by this TNO section. National and international agencies in charge of traffic safety also make grateful use of the knowledge in this department. Jac Wismans has played a crucial role in the development and testing of the MADYMO crash simulation program with an increasing number of applications world-wide. New challenges continue to arise in the area of safety for pedestrians, cyclists, and motorcyclists in collisions with automobiles. At the moment, the problem of whiplash is receiving special attention.
Since 1989, Jac Wismans has also been a part-time professor in the Injury Biomechanics Department at the University of Technology in Eindhoven.

↑ Prof. Dr. J.S.H.M. Wismans

How do we keep blood vessels open?

Kees Kluft (1946) started working for TNO in 1972 at the former Gaubius Institute, which specialized in research on blood and blood vessels. He focuses on a process called fibrinolysis. In the blood system, there is a delicate balance between clot formation and clot dissolution. If the wall of a blood vessel is damaged, substances are released which induce the clotting process. A fibrous netwerk is formed from fibrin to close the wound. The clotting process must, at some point, stop. The clot must also be cleared away as soon as the vessel damage is healed - fibrinolysis. The Kluft group has contributed greatly to unravelling the process and identifying the key substances. Their results are particularly useful in the battle to prevent and treat heart attacks. With age, fatty deposits, or plaques as they are termed, form on the inside of the blood vessel walls. If such a deposit breaks, a clot forms. This can become dangerously large if the anti-clotting mechanism fails or if there is a shortage of substances capable of breaking clots down. The insight gained into the blood system can be used by clinicians and the pharmaceutical industry. In the last several years, they have started to play an increasingly important role in the policy of prevention.
Prof. Dr. Kees Kluft is a part-time professor at the Catholic University of Rome.



↑ Prof. Dr. Kees Kluft

Toppers

Steam-drying: paradox realized

At first glance, steam-drying may seem somewhat paradoxical. After all, steam coming out of a kettle looks fairly moisty, and indeed it is. This type of steam is not suitable for drying, since it will only make a product wetter through condensation.

However, raising the steam's temperature until it gets overheated creates an entirely different condition. To dry a product, overheated steam can be applied to it. The product, which is wet, is heated, so that the water begins to evaporate. The overheated steam cools and absorbs water vapour from the product. As long as the steam in the dryer remains overheated, steam is an excellent medium for drying products. A major advantage of this drying process is that the evaporated water becomes available in the form of steam which has a high energy content which can often be used in other processes.

Early 1997, a joint European project will be completed which aims at exploring the options for steam-drying paper and textiles. The project has resulted in a continuous pilot steam-dryer with which drying speeds can be achieved of five to ten times higher than conventional drying techniques (heated cylinders). An additional advantage of this technique is that higher energy efficiency is obtained provided that the steam generated in the process can be utilized elsewhere. Such utilization requires a process integrated approach. Furthermore, the quality of the products dried according to the new technique can compete with the quality of conventionally dried products. These advantages also apply to products of other materials.

(TNO Institute of Environmental Sciences, Energy Research and Process Innovation, Henk van Deventer)

Small companies go off at score with TNO

Score B.V. is an excellent example of how small companies can develop a successful partnership with TNO. After its first contact with TNO, the company quickly realized that our knowledge and experience in product development were a perfect match with their own plans to expand Score's product range. Score is active in the market for work chairs for industrial environments, and foresaw a stabilization of demand in that market.

In a brainstorming session with TNO, a plan was defined which created new opportunities while staying close enough to Score's core competences. The plan involved convenience products for a broad target group. Score defined several strict requirements: the range was to include functional convenience items which were practical and safe but also attractive, with an image of vitality. And the price had to be right.

Now the 'Score Safe and Easy Products' range is beginning to take shape. The first product was the 'Splash Shower Seat', developed to make the process of taking a shower easier and safer for senior citizens and convalescent patients. Continuing on the same line, the 'Score Bath Seat' was developed, which allowed the user to move into and out of the bath tub safely as well as dry off and get dressed while sitting down. The Bath Seat is mounted on the edge of the tub. The Seat recently won the 'iF Product Design Award Best of Category 1997', a prestigious design prize conferred annually by the 'Industrie Forum Design Hannover' (iF). The Bath Seat had previously been awarded the 'Recognition for Quality Industrial Design 1997'. Other products made jointly by Score and TNO include the 'Score Work Top', the 'Score Trolley', the 'Score Sit-Stand Stool' and the 'Score Office Trolley'.

(TNO Institute of Industrial Technology, Alfred van Elk, Tom van der Horst)

Fri-Jado

Snack-automaton: technical tour de force

Choosing, buying, getting the right snack out of the freezer compartment, taking it to the microwave, heating it up, removing it from the oven, taking it outside. A design that appeals to the client and is plain and simple to use, not to mention vandal-proof. It's the new, advanced warm-snack vending machine from Fri-Jado. TNO Institute of Industrial Technology was the only company deemed capable of coming up with a mechatronic solution - a product with all the requisite qualities, including an acceptable cost price. Colleagues at the TNO Physics and Electronics Laboratory developed a special microwave oven to ensure extra quick heating.

(TNO Institute of Industrial Technology, Niklaas van Hylckama Vlieg)

Computerized moisture diagnosis

An estimated 20 percent of the homes in the Netherlands are affected by moisture and mould. The Secretariats of the Rent Tribunals process between 13,000 to 15,000 complaints every year. In conjunction with and in support of these tribunals, TNO has developed a system that facilitates complaint processing.

The Moisture Diagnosis Expert System 2.0 is a 'knowledge-based' system that is specially designed for moisture and mould problems in houses. The system covers the entire range of damage caused by flaws, design errors and construction mistakes. Damage caused by the complex interaction of building, installation, maintenance and use is also included. The system's joint development by TNO and end-users is a unique feature. This approach was possible because we could use a system developed by TNO that facilitates user-friendly entry of knowledge into expert systems.

The diagnosis system is based on visual information collected through on-site inspection and on information deduced from construction plans. The system is intended to support the user in resolving disputes between tenants and landlords. The support comprises a technical analysis which can be reviewed and put into a report. This ensures uniformity of the Rent Tribunals' diagnoses while the application of knowledge increases the quality and professionalism of the diagnoses. Positive spin-offs are that Rent Tribunals are less vulnerable when experienced staff leave and that training needs are less acute. The diagnosis system is also highly suitable for transferring and immediately implementing conventional or new knowledge on-site. The system contains recent information on subjects such as mould, occupant behaviour and ventilation. In 1997 an assessment will be made of the system as it is applied by the Secretariats of the Rent Tribunals. The system was developed with support from the Ministry of Housing, Spatial Planning and Environment.

(TNO Building and Construction Research, Olaf Adan)

Battlefield Management System for the 'desert fox'

The 'digitization of the battlefield' is in full swing, with information technology for military activities continuing to make rapid headway as a dominant factor. TNO is now involved in introducing the Battlefield Management Systems (BMS) into vehicles of the Royal Netherlands Army. The mobile combat units of the future can rely on sophisticated information technology. Our current goal is to give commanders a better view of the position, situation and fighting strength of their own and of hostile units. A BMS automatically distributes information about a vehicle's situation to the unit's other vehicles as well as other units. BMS can thus be described as a mobile network of vehicle computers which provide information services to commanders in operational military conditions.

In 1996 the Royal Netherlands Army initiated the process of introducing these systems. The first vehicle type to be considered for application of a system was the 'Fennek', an exploration vehicle whose name means 'desert fox'. TNO is involved in the joint venture which was created to analyse all the practical implications of the introduction of a BMS. TNO also examined the functionality and technical feasibility of a BMS. Since the BMS for the Fennek must fit into an integrated command and control infrastructure, the link to other command systems will certainly receive the attention it deserves.

(TNO Physics and Electronics Laboratory, Kees d'Huy)

NS Ultrasonic Company

New generation of rail inspection

In 1997, the new 'Ultrasonic Rail Inspection' train, for which TNO realized the ultrasonic measuring system, goes into operation. The Dutch Railways (NS) Ultrasonic Company will then be able to check at a speed of 75 km per hour for cracks or fractures in the tracks. Now that rail traffic is becoming increasingly busier, the 50 km an hour top speed of the first generation Rail Inspection System - which was also developed by TNO - is considered too slow. The measuring principle used is based on detecting reflected ultrasonic sound pulses. To guarantee the absolute reliability of the rail inspection, measurements are taken at two millimetre intervals, sending sound in different directions through the rails to detect any horizontal and/or vertical faults.

(TNO Institute of Applied Physics, Jaap Roos)

Carbohydrates: the raw material for the detergents of the future

Starch is a highly versatile raw material. The carbohydrate elements from which starch is made up can be converted into useful detergent components, an important class of which are surface-active derivatives, better known as surfactants. The primary reason why this is worthwhile is because one can utilize it as a neutral carbon dioxide raw material. A further reason is that conventional petroleum-based products such as alkylbenzene sulphonates and alkylphenol ethoxylates are poorly biodegradable and may have an adverse impact on the fertility of male organisms.

↑ Research into a soap film based on carbohydrates.

→ TNO was involved in a project to solve vibration problems in a floating buoy off the Columbian coast from which tankers load crude oil.

There is good reason to assume that these common surfactants can be replaced by molecules which have a carbohydrate head group (to dissolve the molecule in water) and a fatty alkyl tail (to absorb fat and dirt). TNO has examined the relationships between the molecular structure, the physical properties and the application potential of surfactants based on inexpensive carbohydrates like glucose and lactose. This has resulted in a methodology which allows the relevant properties of such compounds to be predicted quickly and simply. Major parameters include: solubility, aggregation behaviour (formation of micells, emulsifying properties, etc.) and the minimum concentration required for aggregation. Initial cleaning tests have produced promising results.

(TNO-Netherlands Institute for Carbohydrate Research, Henk van Doren)

Fascinating Columbian adventure

The Bluewater engineering firm faced a problem with a floating buoy off the Columbian coast from which tankers load crude oil. The loading process had to be accelerated. But after an increase in the flow speed, ominous sounds and vibrations inside the buoy made it obvious that something was wrong. The flow patterns in this type of buoy are complex certainly when the buoy is connected to various pipelines. So Bluewater contacted TNO to track down the cause of the problem. Bluewater needed special expertise and measuring equipment, which they found at TNO. We possess internationally recognized expertise in the field of fluid dynamics and vibrations in pipeline systems. Over the years TNO has built up vast experience of calculating and predicting pulsations and vibrations. The major instrument for analysing this type of problem is the PULSIM computer program, developed by TNO. This package and the studies carried out with it enjoy a world-wide reputation.

To identify the cause of the pulsations, TNO performed on-site measurements which indicated that cavities were being created: air bubbles in the liquid which, when they implode near a wall, may cause erosion. Using calculation models, TNO determined where and why high, local flow speeds - combined with pulsations - created cavities. The same programs enabled us to chart what the effect of various remedial steps could be. Ultimately, a range of options was identified, and the most feasible alternative was selected..

(TNO Institute of Applied Physics, Jan Smeulers)

A new look at the washing process

Water, the right detergent and a proper stir in the washing machine is enough to get most clothes clean. This process is so familiar that the suggestion by TNO experts that we do not really understand how it works seems odd. Soap lowers the water's surface tension. Mechanical action enhances the washing effect. That much is clear from the text books. But closer examination at the micro level reveals that things are not as obvious as they seem. Washing with a liquid that has a lower surface tension than that of water is unsuccessful. Fluid mechanics teaches us that the flow speed at the textile/water interface, where the dirt is located, is virtually zero.

Finding out what the washing process actually involves took a Ph.D. research project and plenty of additional research at TNO. The first conclusion was that there is definitely a flow in the threads which is created by the motion of bending and stretching threads which gives them a pumping action.These flows have a decisive effect on the action of the surfactants (soap), and the impact of this was studied in a draining soap film. When a mobile, vertical soap film drains, the surfaces shift downwards. These shifts cause variations in the surface tension at the lower horizontal border of the film. As these variations are smoothed out, sudden movements occur along with increasing migration of thin film elements. In a similar way, it is possible for sudden movements to occur on a textile surface in a detergent solution. Such movements create the washing effect. These new insights may in the future contribute to better washing machines.

(TNO Cleaning Techniques Research Institute, Laboratory of Physical Chemistry of the Technical University of Delft, V.A. Nierstrasz)

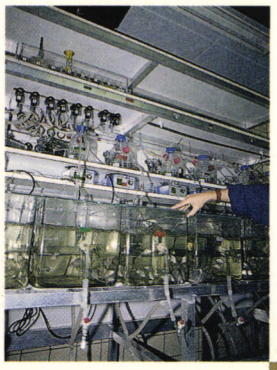
Pseudo-oestrogenic compounds give male carp female sex organs

On 21 November 1996, an article was published in the periodical Nature that caught the attention of many. The article reported the effects of 'pseudo-oestrogen' compounds on the sexual development of young, male carp. When exposed to such substances as alkyl phenols, the male fish developed female sex organs.

This research was carried out jointly by TNO and the Agricultural University of Wageningen. Its significance is linked to growing concern about a possible relationship between exposure to substances in the environment which are biochemically related to sex hormones and a decrease in human fertility which has been suggested by some researchers. Reproductive disorders in some animals described in journals have been related to environmental pollution. These reports have indicated changes in the appearance and operation of the sex organs.

Researchers gratefully used the fact that carp takes a long time before the sexes begin to differentiate themselves from one another through the development of male or female sexual characteristics. The differentiation begins after around fifty days. If the young males are exposed to substances that have oestrogenic effects, they develop female sex organs. The researchers believe that this is sufficient cause to draft regulatory standards.

(TNO Nutrition and Food Research Institute, Sylvia Gimeno)



← Laboratory research on the effect of pseudo-oestrogen on the development of sex organs of male carp.

↓ TNO now combines its conventional practical research with research on fundamental washing processes

Pinocchio has a successor

After many years of faithful service, TNO's family of child dummies from the P-series will be making way for the more modern kids with Q registration numbers. The 'P' stood for the first, wooden child dummy to make history : Pinocchio. The new dummies are not only much more lifelike, they are also equipped with more extensive instrumentation. Whereas the P dummies could only measure velocity, its successors are fully equipped with sensors that measure forces and distortions to better detect any injuries. The dummies in the new Q-series can also be used to study the effects of both frontal and side impact. Child dummies are primarily used to test child car seats.

(TNO Road-Vehicles Research Institute, Marc Beusenberg)

NATO uses Intranet in training exercise

The NATO exercise known as 'Strong Resolve' is scheduled for the spring of 1998. The plan is for commanders to be supported by special Intranet facilities in the execution of their duties. TNO is intensely involved in preparations for this facility, which is an illustration of the application of civilian technology for military purposes.

In phase 1 of the 'AISD programme' (Advanced Information Services Demonstration), the Netherlands cooperates with the United States and the United Kingdom. France will join in phases 2 and 3. The Netherlands' contribution will be the combination and integration of several technologies: ATM (Asynchronous Transfer Mode) basic technology, security of applications and Internet technology in the broad sense of the term. Services will include video-conferencing, real-time video-image enhancement, network management and multi-level secured web search.

The highlight of phase 1 was the international AISD presentation in the United Kingdom and in the Netherlands by the end of 1996. The demonstration showed that the system can be used successfully for teleconferencing and teleworking, including satellite links, and that the electronic mail system is sufficiently secured. Information management with various levels of confidentiality on one and the same web server satisfied all requirements. Integration of our real-time video processor was also successful. Our images files can be opened from any terminal in the AISD network. Phase 1 has now been successfully completed. In phase 2 the focus will shift to military applicability and readiness.

(TNO Physics and Electronics Laboratory, Eric Luiijf)

A green outlook for Philips Sound & Vision

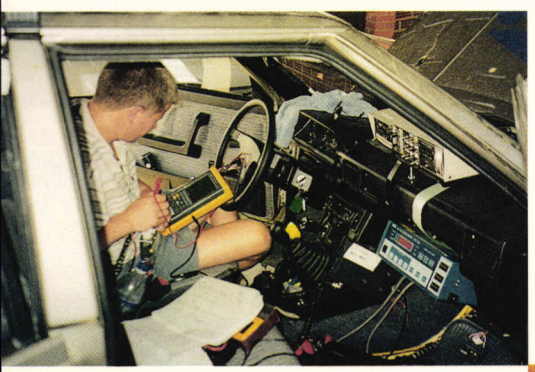
The combination of population growth and rising per capita prosperity could create major environmental problems in the next century if we do not start handling raw materials and energy more efficiently and reduce the negative effects of production and consumption. This implies a factor ten jump in the 'eco-efficiency' for the next 50 years. Radical innovation is inevitable. Fortunately, businesses understand how serious the situation is. In 1995, TNO's Jacqueline Cramer was invited by Philips Sound & Vision/Business Electronics to join a two-year project, the aim of which was to define a strategic approach for environmental management and improve eco-efficiency by a factor of four. This improvement was to be accomplished by incorporating environmental aspects in strategy and planning for the earliest phase of product development. Working with her Philips colleagues, Cramer developed the STRETCH methodology: Selection of sTRategic EnvironmenTal CHallenges. The plan has five steps: identify the major forces determining corporate strategy; define a number of plausible scenarios and define a list of product/market strategies for each scenario; identify environmental opportunities and threats in each scenario; select environmental improvements; and accomplish the environmental improvements for each product/market combination.

The process will enter phase 5 early next year. A major factor in the ultimate decisions will of course be the extent to which new products may reinforce Philips' market position. The new philosophy will give the environment new dimensions in a company. It will be part of strategic policy and decision-making by senior management.

(TNO Centre for Technology and Policy Studies, Jacqueline Cramer)

Where less is better

Much traffic noise is caused by passing trucks and buses. The European Union is responding to this problem by tightening appropriate emission limits while allowing manufacturers sufficient time to adjust their products. To measure noise emissions, the EU makes use of a 'pass-by test'. In 1996, the test's limit was lowered once again by 4 dB(A). The European project, known as PIANO, aimed to examine how truck and bus producers could anticipate these new noise emission limits. The project ran from 1992 to 1996.
The stricter limits push up the costs of production. Every year 300,000 heavy trucks and buses are manufactured in Western Europe. So, the significance of designing and building quieter vehicles is clear.



↑ TNO was involved in a project to adjust the Polish car brand FSO to Westeuropean emission standards.
→ TNO expertise in low-noise construction was applied in the new DAF truck.

Virtually all major European truck manufacturers were represented in the PIANO project. TNO was one of the partners involved. Low-noise design is one of our specialties, which was developed when the Royal Netherlands Navy invited TNO to help develop quieter ships. Another TNO specialty developed over the past few decades is in prevention and reduction of traffic noise. The PIANO project focused on converting research ideas into technical tools which could be applied in the design process. The tools developed by TNO have now been successfully implemented by Fiat and DAF Trucks.

(TNO Institute of Applied Physics, Jan Verheij)

Adjusting Polish cars to Western environmental standards

Early 1995, TNO was asked to contribute to the development of a multi-point fuel injection system for the FSO 1.6L engine. FSO's objective was to reduce emissions to Euro-II level and to add 10 percent to the engine's torque and power. The ultimate goal was to extend the lifetime of the FSO engine, first constructed in the fifties, into the year 2000. The participants in this project included FSO, ABIMEX BV (the FSO importer in the Netherlands), Delphi Energy & Engine Management Systems (representing General Motors) and TNO. TNO had previously joined forces with ABIMEX to adjust the FSO engine so that it met the US'83 emission standards.

Since European legislation has now been significantly tightened with new limit values for CO, HC and NO_x emissions (Euro-II level), it was imperative to make further cuts in the FSO 1.6 litre engine's emissions. This goal was in fact conflicting with the goal of increasing engine power. The solution was found in a multi-point fuel injection system. TNO undertook development and calibration for the system, based on Delphi technology. The engine required internal (combustion chamber) and external (camshaft) modifications. As the entire combustion process was optimized and fine-tuned, both the emissions and power objectives were achieved.

By the end of 1995 FSO was taken over by Daewoo. The Daewoo FSO 1.6L MPFI satisfies the latest emissions standards and will be introduced mid-1997.

(TNO Road-Vehicles Research Institute, Pieter Jan Brandenburg)

Measuring blood pressure without gravity

The future International Space Station (ISS) which is being built by NASA in cooperation with Russia, Europe, Canada an Japan will include a Human Research Facility. This facility will allow investigators to conduct research on human subjects concerning adaptation to the space environment and to monitor the crew from a health perspective. Thus, risks associated with human space flight may be quantified and eventually reduced. In many cases a continuous recording of blood pressure and ECG is essential.

The Portapres developed by TNO has been selected by NASA and its main contractor KRUG Life Sciences, Houston, to fulfill this function in the Human Research Facility, since it provides a noninvasive measurement of blood pressure in a continuous and ambulatory (compact, light-weight, battery powered) fashion. Portapres is unique in its capabilities.

The Portapres Model 3.1 which is currently being developed by TNO for NASA will be a modified version of a version which has been developed for the French Space Agency CNES-Toulouse for space flight on the MIR Space Station, and which has been succesfully used in the CASSIOPEE mission in 1996. The new model will additionally include an integrated ECG measurement and storage system, along with full control of Portapres and real time monitoring of the measurement data by the Human Research Facility central computer. TNO will manufacture ten complete systems, five of them to be used in space, the other five are meant for training purposes.

(TNO Institute of Applied Physics, Jos Settels)

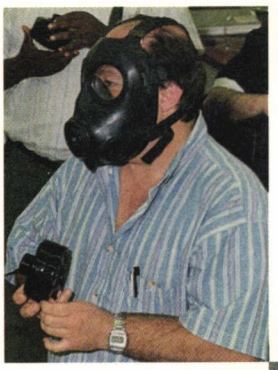
Chemical weapons betrayed by fingerprints in blood

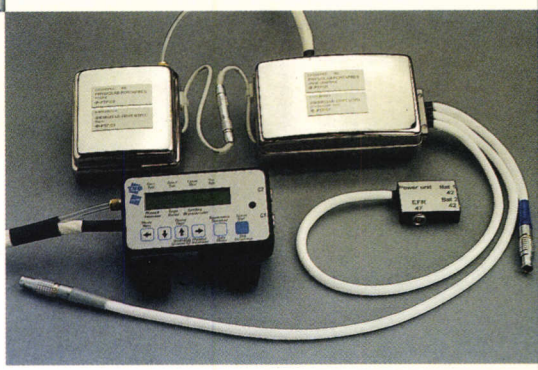
Were Gulf War soldiers exposed to chemical agents? Which agents were used in the terrorist attack on the Tokyo subway? TNO had already developed a method for detecting mustard gas exposure in alleged victims, even several weeks after the event. Now we have augmented this achievement by devising a way to establish exposure to the highly hazardous nerve gas Sarin. This method, which experts term unique in the world, enabled TNO to irrefutably establish exposure to a nerve gas sharing the structural properties of Sarin (more generally, an organophosphate anticholinesterase) shortly after the 1995 Tokyo tragedy.

Our detection methods are based on agents bound to DNA or to certain proteins in the blood. They leave a chemical fingerprint behind. Development was made possible with support from the Dutch and German Defence Ministries and the US Department of Defense.

The methods are crucial for monitoring compliance with the Chemical Weapons Convention which is now law. Their significance is compounded as they allow identification not only of production (especially illicit production) of such agents, but also of the people who make them. The new method will also be crucial for diagnosing accute exposure to nerve agents and for optimizing treatment. Since some pesticides (organophosphate pesticides) are closely related to nerve gases, the newly developed method may also be helpful for monitoring human health.

(TNO Prins Maurits Laboratory, Martine Polhuijs)





← TNO instructing inspectors who have to monitor compliance with the ban on chemical weapons.

↓ TNO developed a portable system for continuous measurement of blood pressure and ECG for the 'human resource facility' in the International Space Station Alpha.

Raising the recycling percentage of glass

In glass production, control of the oxidation level (redox) is vital to ensure stability in the melting process. The oxidation level can be characterized by partial oxygen pressure in the melt. The oxygen pressure in the glass melt is highly influential in determining the properties of the glass which is being formed. This is particularly so for the colour of the glass. Where oxygen pressure is too low, the glass will be brown instead of green. The pressure level can be adjusted by adding certain substances. But this, of course, requires the pressure level to be known.

In many European countries, around 70 percent of glass is remelted. The large fraction of recycled glass and the related input of organic contaminants affect oxygen pressure in the melt. This causes the process parameters to be less clearly defined. To research how the process could be adjusted, the project 'Redox control for glass packaging recycling' was initiated in 1994 as part of the EUREKA programme 'Packaging and the Environment in Europe'. Participants included Danone-BSN (France), Heraeus Electro-Nite (Belgium) and, from the Netherlands, Vereenigde Glasfabrieken, Maltha and TNO. The result was Rapidox, a new measurement system which determines the oxygen pressure level in the glass melt. Rapidox is currently being marketed by Heraeus Electro-Nite, which owns the patent for the invention and exploits the systems also on behalf of TNO and BSN. The system comprises a sensor for measuring oxygen pressure in the melt and a mini glass oven which can melt glass up to 1500 degrees Celsius. This combination can be applied in various stages of the production process. Rapidox also includes a computer program which can predict the effects of certain additives. Field experiments at Danone-BSN have demonstrated that Rapidox delivers reliable results, enabling the industry to raise the recycling percentage of glass.

(TNO Institute of Applied Physics, Anne-Jan Faber)

Epidemiology of the food and cancer relationship

TNO's Netherlands Cohort Study on Nutrition and Cancer, a joint project initiated in 1986 with the Maastricht University, produces fascinating results. The research focuses on the relationship between food consumption and health. Where statistics involve minute probabilities, large numbers must be researched to make the conclusions convincing. That is why the project has been trakcing more than 120,000 Netherlands inhabitants for over ten years.

Over the past few decades, numerous suggestions have been made regarding the relationship between the consumption of certain food products and the occurrence and prevention of certain types of cancer. The suggestions and claims that have been made are of immense importance to individual citizens as well as institutions and companies. All in all, there is an acute need for more certainty on these relationships. The questions are complex, and various factors are involved that are frequently hard to define. To draw reliable conclusions, large-scale epidemiological research is required.

Some suggestions and claims have already been proven false. No relationship, for example, could be shown between fat consumption and breast cancer. Collected data also failed to substantiate any positive effect caused by flavonoids in fruit and vegetables. On the other hand, there are major indications that fruit and vegetable consumption have a definite preventive impact. This impact, however, is apparently not caused by flavonoids. An alleged protective effect of tea was another claim that was recently disproved by overwhelming numerical data: experts' doubts were confirmed.

The significance of this research is illustrated by the four Ph.D. theses it has already produced. Several more are being prepared. The project will continue for at least another ten years.

(TNO Nutrition and Food Research Institute, Sandra Bausch-Goldbohm)

Royal Netherlands Army

Shelters for peace keeping operations

At the request of the Engineer Training Centre of the Royal Netherlands Army, TNO investigated the level of protection offered by the shelters used in peace keeping operations with the aim to produce a handbook of regulations for protective constructions. We started testing various constructions. The investigations revealed, among other things, a way to make better roof constructions, with a higher degree of protection, while simultaneously reducing the transport volume by half.

(TNO Prins Maurits Laboratory, Boy Kodde and Philip van Dongen)

A giant with feet of steel

In Portugal, an impressive bridge-building feat is nearing completion. A bridge over the River Tagus is scheduled to be in place by February 1998. The bridge will be 18 kilometres long. Navaponte, the main contractor, hired TNO to monitor pile driving operations. The 6.5 km long central section of the Vasco da Gama bridge consists of 648 steel piles, each weighing over 2,000 metric tonnes, and having a diameter of 1.7 metres.

↑ The SUMMIT system is applied in seismic field research on Belgian subsoil.

→ TNO made a detailed analysis of the pile-driving process as part of the construction of the Vasco da Gama bridge over the River Tagus.

TNO has an international reputation for testing the integrity and load-bearing capacity of piles. The Foundation Pile Diagnostic System (FPDS), developed by TNO, is the world's most complete measurement system of its kind. Since pile-driving has to be done right the first time, this system is growing rapidly in popularity all over the world. The result of mistakes is major expense. The FPDS system monitors the pile-driving process and determines the pile's load-bearing capacity and integrity after it has been driven.

Initially, TNO was called in to determine the static load-bearing capacity of piles at four separate sites. This was so successful that TNO was subsequently asked to make a detailed analysis of the entire pile-driving process. So Vasco da Gama can rest in peace: the bridge named after him will stand on solid ground.

(TNO Building and Construction Research, Peter Middendorp)

Charting Belgian clay

The Belgian National Authority for Radioactive Waste and Enriched Fissile Material (NIRAS) was interested in exploring the geological properties of a thick layer of clay in the Belgian subsoil, known as 'Boom's clay'. TNO was invited to perform a seismic examination to prepare a detailed geological chart of this formation. The part of the subsoil to be charted ranged from around 80 to 1,000 metres under the surface. Fault lines were to be charted as well. Considering the size of the project, this was quite a challenge.

Seismic research can be briefly summarized as follows. Sound waves created by minor explosions (or special vibrators) move downwards. These waves are partially reflected at the interface of layers that have different acoustic properties. By measuring the time of reflection, the depth can be derived. The echos are recorded on the surface by geophones.
In the Belgian project around 60 kilometres of seismic profile was measured. Use was made of the data acquisition and telemetrics system SUMMIT, developed by TNO jointly with Deutsche Montan Technik. SUMMIT comprises hundreds of small, portable units which digitize, save, and pre-process signals received by the geophones. The geophones subsequently transmit the signals to a central field unit.

In TNO's field office, the data were converted into a rough chart of the subsoil and were subsequently sent to the processing centre at TNO. Initial analysis revealed that the quality of the measurements is such that the project can be successfully completed in the short term.

(Netherlands Institute of Applied Geoscienc TNO - National Geological Survey, Sjef Meeskes)

Bioscreens confine pollution

To cleanse the Dutch soil of the contaminants we have been putting in it for years, could by some estimates cost about NLG 100 billion - if conventional methods are applied. Reason enough to attempt and find an approach which will be less onerous. Remediation using micro-organisms offers attractive opportunities. Examples in the Netherlands and abroad show that micro-organisms are capable of limiting the spread of certain contaminations, as well as removing these contaminants, thus reducing their environmental risk.

That is why TNO initiated research on the effectiveness of 'bioscreens'. A bioscreen is essentially a groove surrounding a contaminated site. The groove is filled with biologically active, absorbent material that is sufficiently permeable. A variant of the bioscreen is the so-called 'activated zone' in which no soil is excavated, but where local micro-organisms are activated through the right additives.

Research at TNO focuses on the decomposition of BTEX substances (benzene, toluene, ethyl benzene and xylene) and chlorocarbohydrates (including PER, TRI and vinyl chloride). In the Dutch National NOBIS programme, research is focusing on how these substances can be degraded. The hazardous substances benzene and vinyl chloride are proving particularly hard to break down. The application of bioscreens will therefore require further research.

(TNO Institute of Environmental Sciences, Energy Research and Process Innovation, Huub Rijnaarts)

Designing ships in virtual environments

TNO is investigating what opportunities virtual environments (VES) may offer for designing ship control centres, such as the bridge and operation room. All it takes to enter the virtual environment is a special VE helmet. The computer tracks the person's movements and displays the appropriate images inside the helmet. This allows a designer or user to assess the functionality of the bridge. By adding a dynamic-functional model, more procedures can be evaluated, such as the procedure for lowering lifeboats into the sea or taking on supplies.

At the request of the Royal Netherlands Navy, TNO evaluated several bridge design models for the Air Defence and Command Frigate soon to be built. Critical points in the design included the view from the bridge and the bridge wings. Virtual environment techniques allowed an assessment to be made of the allocation of space on the bridge and the view from the wings, from the perspective of several different tasks.

TNO is actively expanding these facilities by introducing options for picking up and manipulating objects in the virtual environment in favour of more interactive tasks. These techniques are expected to result in major changes in ship design methods.

(TNO Human Factors Research Institute, Peter Werkhoven)

← Virtual environment technology opens new doors for ship designers.

↓ Field research into soil pollution.

ICES

Distribution demands action

In 1996, the INCOMAAS project was completed. The objective was to be well prepared for the expected sharp increase in future container transport handled at the western ports of Rotterdam: the Maasvlakte. The important Main Port position of Rotterdam and the related Dutch distribution function should not stagnate. In the INCOMAAS project TNO was in charge of the part of the project concerning the impact of traffic management systems on container road transport in the south of the Rotterdam region. TNO analysed proposed improvements of the logistic chains, better utilizing the road system for freight transport and the implications of the Trans European Inland Terminals in the Dutch hinterland. One conclusion is that a better utilization of off-peak capacity of the roads has a great potential. (TNO Inro, Roel ter Brugge)

Mobility for senior citizens

In the next few years, senior citizens (over 55) will be a growing part of the Netherlands population. The characteristics of this part of the population are changing: they become more vocal, healthier and affluent. In addition, the seniors of the future will have grown up with cars. It is only natural for them to want to keep the mobility they are accustomed to as long as they can. To gain insight into senior citizens' mobility, the Ministry of Transport, Public Works and Water Management asked TNO to outline supply trends and possible implications on the traffic and transport sector. The key questions are: what trends will affect mobility and mobility behaviour of the senior citizen of the future, and what opportunities may the government have to influence supply-side trends?

The research identified fourteen trends in transport systems, driving tasks, vehicles and substitute mobility (such as teleshopping). The most significant supply-side trends having a positive impact on senior citizens' mobility are in the integration of subsystems (linking various transport systems together to form a door-to-door model), improved access to and comfort in vehicles as well as the integration of cars and collective passenger transport systems. In particular senior citizens with physical limitations will benefit from these changes, but ultimately the changes will help everyone. The main focus of senior citizens policy will therefore be the integration in general mobility policy .

(TNO Road-Vehicles Research Institute, Aleid Hekstra)

New method to predict risk of heart attack

Increased serum cholesterol levels indicate a heightened risk of heart attack. Cholesterol, however, is not the only factor. Most heart attack victims do not have high serum cholesterol levels. This indicates that the predictive value of a determination of cholesterol levels and the preventive value of ways to reduce cholesterol levels is limited. TNO participated in an international research programme with the aim to evaluate a method that is much more effective in predicting heart attacks.

Atherosclerosis (hardening of the arteries) is accompanied by inflammation processes. These processes can be identified by a heightened concentration of a protein known as C-Reactive Protein, or CRP. An extensive study involving 2,000 angina pectoris victims and 18 European centres revealed that there is a clear link between high CRP levels and a heart attack risk. The conclusion is that CRP is a better indicator of the risk of cardiovascular disease than cholesterol. This discovery shows the way forward for further studies: better risk estimates may be obtained by combining various risk indicators and risk factors; CRP may be used as an indicator of pre-clinical atherosclerosis; and inflammation processes may be slowed to prevent heart attacks.

(TNO Prevention and Health, Frits Haverkate)

Oil industry up to its neck in salt water

Oil extraction generates water as a by-product. The amount of water extracted by major oil producers may even equal the amount of oil produced. Since numerous fields have been exploited for many years, the amount of water relative to oil may be expected to increase in the future.

This water by-product creates serious environmental problems. The salt content is so high that the water cannot be discharged onto surface water without treatment. And since treatment is expensive, the search for alternatives is intense.

The most obvious alternative is to put the water back where it came from: re-injection into deep geological formations. Injection in itself is not the main problem. A major problem is how to establish the required infrastructure for treatment, purification and injection. One of the most difficult questions is how an injection area could change over time. Injected water contains a certain percentage of microscopic particles which will clog the pores of the rock, so that pumping the water into the ground will take more effort as time goes on.

TNO has designed a computer model to optimize the injection infrastructure. The model was designed jointly with and at the request of Shell Research & Technology Services in the Netherlands. It is intended to predict the effect of water injection in a given geological formation and how much pumping capacity will be required to inject the predicted amounts of salt water. Plans are to use the model world-wide in Shell subsidiaries. The development will be completed in 1997.

(TNO Institute of Applied Geoscience, Emile Elewaut)

How to find peanuts in food?

An estimated one in every 10,000 people in the Netherlands is, to some extent, allergic to substances contained in peanuts. Until now we know little about peanut allergies, and treatment is unavailable. Symptoms are often more serious than other food allergies. Cases have been reported in which consumption of a single peanut caused death through anaphylactic shock.

Many products are known to contain peanuts. Others are less clear, such as cookies, chocolate spreads, soups and breakfast cereal. Sometimes small quantities of peanut substances may accidentally end up in a product. Production equipment used for peanut and non-peanut products must be thoroughly cleaned before switching from one to the other.

Until recently, the food industry, retail outlets and supermarkets did not have any instrument to check the presence of peanuts in food products. This prompted TNO to develop a quick and simple method based on the use of highly specific antibodies extracted from rabbits. The substances to be analysed are brought into contact with the antibodies. This reveals the quantity of peanut present in the product. This method, available in a test kit, is the first in the world that can demonstrate the presence of very small quantities of peanut in various products. The product is now being used by food companies and retail stores both in the Netherlands and abroad.

(TNO Nutrition and Food Research Institute, Stef Koppelman)

Glazier company Cor Buist, Groningen

Helping the glazier

Glaziers involved in renovations and restorations are often forced to perform heavy lifting work. To alleviate some of the unhealthy physical load, NIA TNO BV was commissioned by the Stichting Arbouw (the National Organisation for Health and Safety in the Construction Industry) and the Collective Labour Agreement parties to work closely with glaziers and develop some effective devices. A glass pulley does away with the need for manual lifting of the panes when loading or unloading the truck. The glass cart provides a trouble-free means of transporting panes horizontally, up to a mass of 200 kg. With the help of a lifting device and scaffolding on rollers, vertical transportation at the site need not cause unnecessary strain. The glaziers are very happy with these devices.

(NIA TNO BV, Robin Bronkhorst)

TNO Pharma takes off

Bringing new drugs to the market takes substantial time and investment, both to find substances that may have a specific medical effect and to test that effect and safety.

Pharmaceutical companies therefore have an obvious vested interest in shortening the 'time to market' of their products. And they are not the only ones. The user will also benefit from the speediest possible availability of new drugs. Research and development costs often make up 15 percent to 20 percent of pharmaceutical companies' budget. This makes the pharmaceutical industry one of the most active industries in research and development. The expenditure is so substantial that it can only be made where there are world-wide sales to support it. Estimates indicate that pharmaceutical research and development to be contracted out is a $3 billion market worldwide. This market is expected to grow by at least 10 percent annually over the next few years. Opportunities for TNO are numerous.

TNO Pharma got under way on 1 June 1996. Its major activity is to coordinate existing activities for the pharmaceutical industry and to adjust supply with market demand. TNO Pharma will also promote its services more actively than in the past in the pharmaceutical industry. The range of TNO products for the pharmaceutical industry encompasses virtually the entire research and development path, and is extraordinarily broad. TNO has fundamental expertise in the causes and treatment options for a range of diseases, particularly chronic immunologically based diseases and diseases relating to blood vessels and the connective tissue of several major organs. Specialist knowledge is also available on chemical analysis of substances in complex biological matrices. TNO Pharma also has extensive expertise in toxicity research on drugs. A facility is available for research in a model environment on how pharmaceutical substances work while they are in the digestive system. This research can be performed in a unique, computer-driven model of the gastro intestinal system that allows an accurate simulation of natural digestive processes. TNO Pharma also has sophisticated and varied models for conditions relating to the central nervous system, the respiratory system and the skin.

The potential of TNO Pharma to become one of the pharmaceutical industry's most attractive partners is underlined by a portfolio of such breadth and depth that TNO is able to respond to the increasing trend amongst pharmaceutical companies towards outsourcing a greater portion of their R&D. A few examples follow of the kind of work we have undertaken to this end.

The previous annual report revealed the success TNO researchers had in identifying a remarkable stress protein that seems to occur in relatively high concentrations in the affected myeline of Multiple Sclerosis patients. This discovery has attracted widespread international attention and has opened the door to potential treatment. The availability of a broad range of analysis techniques played a significant role. Follow-up research is under way. Long-term research programmes have given TNO Pharma researchers more insight into the processes that lead to the creation of thrombi in the blood vessels, and a few key substances that are involved in fibrinolysis have been identified. Colleagues have developed a method to reveal hypercholesterolaemia at a very early stage. Page 31 contains a report on a new method that can determine the likelihood of a heart attack occurring. It is a method that is based on measuring C-Reactive Protein, a protein that occurs in increased concentrations as a result of atherosclerotic infections in the wall of a blood vessel.
We are working on an entirely new technique to administer vaccines that no longer involve piercing the skin, but on simply swallowing. In response to a request from the WHO, research has been carried out into a method to effect a genetic change in lactic acid bacteria so that the proteins that feature in a number of notorious pathogens are manufactured. These are then introduced within their cell membrane into the defence system so that it becomes activated. Such a vaccine can, in a manner of speaking, be taken with yoghurt.

TNO Pharma is a point of focus within TNO where a number of institutes collaborate to serve a common market. These institutes are TNO Prevention and Health, TNO Nutrition and Food Research Institute and TNO's Prins Maurits Laboratory. The first of

these concentrates on the nature of a range of diseases as well as methods for prevention and treatment. This is research that involves many direct and indirect pharmaceutical features, including the development of new medicines and diagnostics. TNO Nutrition and Food Research Institute is world famous for its toxicology research, and operates very successfully in this area on the Japanese market. In addition, it has a very sophisticated instrumentation that can carry out biochemical analyses. TNO's Prins Maurits Laboratory has a very special role. It is one of TNO's defence institutes and specializes in protection against biological and chemical weapons. The expertise that is derived from such research provides an important supplement to the knowledge that is available at the other institutes.

Rapid prototyping

In the nineties a short time to market is one of the most decisive competition parameters to the manufacturing industry. TNO's task is to define solutions for making products not only cheaper and better, but also faster. The general trends are unmistakable. The number of variations of a single product marketed in 1990 doubled relative to 1970. The complexity of the average product also doubled in the same period. By contrast, product lifespan and required delivery time dropped by half in that period.

The initial stage of an innovation process has taken on new significance in this multi-dimensional competitive scenario. In the development stage for a new product, for instance, an estimated 80 percent of product quality and 70 percent of cost price are determined. The significance of a short time to market is illustrated as total profit earned on many products will drop by 30 percent if the products are marketed six months later.

Product development has long been a specialty of the TNO Institute of Industrial Technology. Conventionally, there was first a concept stage, followed by a design stage. Then came the engineering stage and a zero series. After a test stage, production started. This process can be accelerated with CAD/CAM technology. Further acceleration can be achieved by allowing the different stages in the product development process to partially overlap. This will allow any problems that may arise to be discovered sooner. This solution, known as concurrent engineering, shifts strategic decision points forward.

For concurrent engineering to work, it is crucial for all participants in the process to have clear and unequivocal information throughout the process. It is this need for information that is met by rapid prototyping, potentially in combination with virtual or physical representation. Not surprisingly, rapid prototyping has generated widespread interest in recent years. The prototype is the most accurate possible representation of the final product. Conventionally, manufacturing took time to milling, turning, grinding, and moulding. It also took efforts, and mistakes were easily made.

Wherever possible, this stage was simply skipped - sometimes with disastrous results. But now the link from digitised three-dimensional models with computer-driven design techniques makes it possible to produce products even with complex designs in a short period of time.

Over the past ten years, several different methods have become available which share the common trait that they build the prototype layer by layer. These methods are used primarily where only one model is required. Where there is a need for more than one model, the cost factor often makes it advisable to use the primary prototype as a model for the manufacture of a special mould (which itself is made with rapid prototyping techniques). The mould is then used to make a larger series.

TNO Institute of Industrial Technology's Product Manufacturing Division has broad experience with these techniques in their applications for numerous purposes and clients. Fused Deposition Modelling, involving layer by layer construction through extrusion of filamentary material, is one of the methods TNO Institute of Industrial Technology applies. Ubbink, a Dutch firm, faced the task of developing an outlet for a flue gas exhaust system. The structure had to be such that no icicles would develop, and it had to meet aerodynamic standards. An FDM prototype was used to define the aerodynamic properties.

TNO Road-Vehicles Research Institute uses dummies to perform collision tests. The shoulder structure of existing dummies was adapted to simulate a child since a entirely new series of child dummies for side collision tests was not yet available. Vacuum moulding technology was used to mould several shoulders from relatively soft materials that had absorbent qualities. After the collision experiments, the material with the proper degree of hardness was selected.

Not long ago, Solvay Duphar introduced a new hormone substitute therapy for middle-aged women. TNO Institute of Industrial Technology specially developed a deluxe, re-usable blister holder. A sister model/prototype was

manufactured, and ten models were vacuum moulded in a silicon mould. Solvay Duphar took the results to several sales organisations abroad to assess market response at an early stage. The final result was a substantial reduction of throughput time and of start-up costs.
Over the past few years, numerous companies have successfully hired TNO Institute of Industrial Technology for the manufacture of form models to assess such aspects as image and ergonomics, functional models to test technical feasibility and prototypes as a final check on size accuracy and tolerance and to assess production and assembly properties.

Rapid prototyping, of course, is not the only solution for the time-to-market issue. When production starts, for instance, the required tools are a major concern. Manufacture of these tools must meet standards of quality and speed. This takes us to the field of rapid tooling, which is still developing. The first steps, however, have been taken. TNO Institute of Industrial Technology also covers the assembly stage. Werndl, a German company, wished to reinforce its market leader position in Europe through the introduction of a new line of office furniture. To obtain meaningful responses from the market, Werndl needed eight furniture prototypes, which were not to be distinguished from real products. TNO Institute of Industrial Technology met this need without having to develop special tools. The solution was CAD/LMT/CAM and rapid prototyping techniques.

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