

# Annual review 1994



Netherlands  
Organization for  
Applied Scientific  
Research (TNO)

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Applied Scientific  
Research (TNO)

# Annual review 1994





## Colophon

### PRODUCTION AND COORDINATION

TNO Corporate Communications Department

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*Photograph on page 25*

TNO Human Factors Research Institute

*Photograph on page 30*

ESA, Noordwijk

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*Preparatory research:*

Jacques Bontje ('Lakerveld Innovatief')

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*This report is an abridged translation of the original TNO annual report in the Dutch language. In matters of interpretation the Dutch text will prevail.*





## Introduction

Dear reader,

I'm pleased to present to you the results of the Netherlands Organization for Applied Scientific Research (TNO) for the year 1994. As an independent knowledge-based organization we offer services to Dutch and foreign clients, including both companies and government bodies. Because of TNO's unique position in the Dutch knowledge infrastructure, the Dutch government lends financial support to TNO for the exploration of new fields of technology and the acquisition of new expertise.

In 1994, turnover generated by contract research totalled NLG 448 million (approximately 300 million US dollars), 25 per cent of which can be attributed to foreign clients. For more detailed information please see the paragraph headed 'Ins & Outs' in this review on page 12.

Foreign clients have always shown an interest in TNO expertise, but only recently has TNO adopted a more active policy with regard to foreign markets. In the markets in which TNO operates, geographical borders have evaporated. Our clients now search worldwide for the knowledge and technology they need.

Competition in the R&D market is therefore becoming fiercer. At the same time, the risks entailed in investing in R&D activities are growing. If we at TNO are to maintain our strong position, we must ensure that our R&D and knowledge products meet the highest international standards. In order to keep risks at an acceptable level, we must expand our markets.

TNO's position on the international market is related to its position on the Dutch market and to those sectors of the Dutch economy engaged in a high level of international activity. TNO is therefore particularly active in fields such as transport and logistics, physical planning, food production and agro-technology, environmental and energy technology, industrial safety and water resources management.



TNO's international marketing policy depends on the regions of the world concerned. In Western Europe and the United States our aim is to build up and strengthen our relationship with those companies investing substantial sums in R&D. Most TNO institutes have already established a position in these two regions. In Central and Eastern Europe we are involved in carrying out projects funded from bilateral and multilateral sources. In the near future TNO will be establishing a branch office in Prague. In India TNO has set up joint ventures in the field of industrial safety and oil and gas exploration and production. We also run projects in the field of environmental control and production technology. Opportunities are plentiful in the Asia Pacific region. We have set up a sales and marketing office in Tokyo. In this region, particular areas of interest are food and food safety, pharmaceuticals and the automotive industry. Furthermore, interest is taken in the knowledge we have to offer in fields such as instrumental analysis, environmental control and materials research.

We live in a global village. In the centre of that village is a pump feeded by a variety of sources full of knowledge. It's our aim that TNO is one of them.

**F.E. Mathijsen Gerst, M.Sc.,**  
*president of the TNO Board of Management*



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## Supervisory Board

(composition as at 1 January 1995)

Dr. Th. Quené, *chairman*  
Prof.dr. P.M.E.M. van der Grinten  
J.J. Kaptein, M.Sc.  
Prof.dr. R.A. de Moor  
Dr. P. Ros  
J.H.S. van Ruiten  
R.J. de Wijkerslooth de Weerdesteyn, M.Sc.

## Board of Management

(composition as at 1 January 1995)

F.E. Mathijssen Gerst, M.Sc., *president*  
C.M.N. Belderbos, M.Sc.  
Dr. P. Folstar  
F.Th. Gubbi, M.Sc.  
K. Vos, M.Sc.

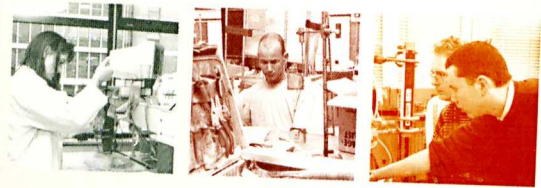
7

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The Netherlands  
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Chairman: Dr. J. J. van der Vliet



Member: Dr. J. J. van der Vliet

Member: Dr. J. J. van der Vliet

Member: Dr. J. J. van der Vliet

Member: Dr. J. J. van der Vliet

Member: Dr. J. J. van der Vliet

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Member: Dr. J. J. van der Vliet

Member: Dr. J. J. van der Vliet



## Key figures

In millions of Dutch guilders (unless stated otherwise)

		1994	1993	9
<b>INCOME</b>	TNO: Operating income	774.3	783.0	
	Turnover (excl. VAT)	745.1	760.0	
	Of which:			
	Turnover industrial-technology institutes (excl. VAT)	494.3	478.9	
	Consisting of:			
	Government basic and programme-related financing	133.9	128.7*)	
	Contract research	360.4	350.2*)	
<b>RESULT</b>	Result	5.5	9.9	
	Operating result	26.9	2.0	
	Depreciation of tangible fixed assets	87.8	69.0	
	Other means of investment	7.5	1.4	
	Cash flow	100.8	80.3	
<b>CAPITAL EXPENDITURE</b>	Capital expenditure in intangible fixed assets	0.1	-	
	Capital expenditure in buildings and fixed technical installations	14.2	17.0	
	Capital expenditure in equipment	37.7	39.5	
	Capital expenditure in tangible fixed assets as % of turnover	7.0%	7.4%	
<b>PERSONNEL</b>	Average number of employees (in man years)	4500	4750	
	Personnel costs	398.6	439.3	

\*) Adjusted for the purpose of comparing.



## Balance sheet as at 31 December 1994

After location of result (in thousands of Dutch guilders)

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	31 DECEMBER 1994	31 DECEMBER 1993
<b>FIXED ASSETS</b>		
Intangible fixed assets	5,900	11,700
Tangible fixed assets	414,088	459,763
Financial fixed assets	73,179	61,284
	493,167	532,747
<b>CURRENT ASSETS</b>		
Stocks and work in progress	14,006	27,756
Accounts receivable	141,440	117,264
Cash	106,106	71,139
	261,552	216,159
<b>CURRENT LIABILITIES</b>		
	-/- 160,525	-/- 136,133
<b>OPERATING CAPITAL</b>		
	101,027	80,026
<b>TOTAL</b>		
	594,194	612,773
Financed as follows:		
<b>EQUITY</b>		
EQUITY	401,415	395,908
INVESTMENT FUNDS EQUALIZATION ACCOUNT	27,967	35,547
PROVISIONS	162,644	177,013
LONG-TERM DEBTS	2,168	4,305
<b>TOTAL</b>		
	594,194	612,773



# Profit and loss account 1994

(in thousands of Dutch guilders)

	1994	1993
Turnover	745,104	760,035
Other operating income	29,212	22,945
<b>OPERATING INCOME</b>	<b>774,316</b>	<b>782,980</b>
Personnel costs	421,328	471,696
Direct project costs	113,539	105,090
Other operating costs	120,969	129,665
Depreciation of intangible fixed assets	33	-
Depreciation of tangible fixed assets	87,834	68,992
Contributions issued	3,700	5,564
<b>OPERATING COSTS</b>	<b>-/- 747,403</b>	<b>-/- 781,007</b>
<b>OPERATING RESULT</b>	<b>26,913</b>	<b>1,973</b>
<b>INCOME FROM FINANCIAL FIXED ASSETS</b>	<b>3,850</b>	<b>3,455</b>
<b>INTEREST RECEIVED</b>	<b>5,595</b>	<b>4,513</b>
<b>INTEREST PAID</b>	<b>-/- 322</b>	<b>-/- 31</b>
<b>OPERATING RESULT</b>	<b>36,036</b>	<b>9,910</b>
<b>EXTRAORDINARY COSTS</b>	<b>-/- 30,529</b>	<b>-</b>
<b>RESULT</b>	<b>5,507</b>	<b>9,910</b>



# Ins & outs

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*TNO is a knowledge-based service organization. More than 4,000 TNO staff are active in exploring the practical utilization of scientific and technical knowledge. As one of the largest European contract research organizations, TNO's role often involves acting as an interface in the innovation chain between basic research and practical applications.*

## Mission and positioning

TNO's mission focuses on reinforcing the innovative and competitive power of trade and industry and supporting solutions to problems of social interest. TNO's main activity is contract research. Many of those who approach TNO with projects are individual companies or groups of companies that share common interests. The Dutch government is a major client as well.

Valuable knowledge honed to fit market needs puts TNO in a key position to provide added value as a partner in research and development processes. This potential is the result of an on-going process of articulating questions, exploring scientific and technological issues and performing strategic exploratory research. TNO invests in knowledge - which later meets needs expressed in projects. Short-term activities follow naturally from long-term activities.

As a knowledge-based organization, TNO's core activities revolve around acquiring, processing, distributing and applying knowledge. TNO translates knowledge into products, processes and recommendations and into hardware and software.

## Technology portfolio

The value of TNO is substantially determined by its 'strategic technology portfolio', which is constantly updated with knowledge from external and internal sources and which is itself the source for meeting concrete knowledge needs. In 1994, the portfolio comprised about 400 technologies. Their value is assessed continuously, since trends in the market and in science and technology require alertness and the willingness to develop new areas of knowledge and to downscale others. Development and management of the technology portfolio are key activities in TNO's strategy, which was presented in 1994 in the strategic report entitled *Making technology work*.

Part of the content of the technology portfolio is protected by patent. TNO's patent policy is strict and strategic. In many cases the clients are the ones who patent the results of R&D conducted by TNO. In 1994, TNO owned about 200 patented findings related to a total of about 600 patents. In the same year there were about 1,000 patent applications pending.



# Input

*Acquiring knowledge and building up expertise are essential input activities of TNO.*

## Knowledge input

Only a few of the aspects of knowledge input can be quantified. One of them is the inflow of new staff, 153 in 1994. Of these staff, 84 had an academic background whilst 31 were polytechnic graduates.

Globally, 98 percent of new knowledge is generated outside the Netherlands. In making direct contributions to the world knowledge reservoir in key fields, TNO not only has access to these sources but is also able to assess the value to Dutch companies of knowledge generated around the world. And to apply it.

### Universities

TNO's mission implies a role of interface and transformation between the world of basic research and that of knowledge utilization. A strategic and intense relationship with Dutch universities is a

natural part of this pattern. Accordingly, there may be said to be a major inflow of knowledge via the broad and multi-faceted network in which TNO and the Dutch universities cooperate. The numerous informal working relationships result in projects, which often lead to more formalized, structural and personal joint ventures. An overview of several major structural relationships, the 'TNO Centres', is shown in Table 1. New centres are being established. TNO views them as 'Centres of Excellence'.

In addition, the TNO Institute of Applied Physics maintains a long-standing and fruitful relationship with the Faculty of Applied Physics of Delft University of Technology.

### Strategic knowledge development

Eight ICES projects (Interdepartmental Committee for Economic Structural Improvement) were launched in 1994. The aim of these large national projects - which will continue until 1999 - is to strengthen the economic structure and the knowledge infrastructure of the Netherlands. They are also of importance for TNO's knowledge development (for an overview, see table 2).

Table 1: Formalized, structural cooperations between TNO and the Dutch universities in 1994

Cooperation title	University	TNO institute
TNO-RUL Centre for Phytotechnology	Leiden University	TNO Nutrition and Food Research Institute
TNO Centre for Structure Elucidation and Instrumental Analysis	Leiden University	TNO Nutrition and Food Research Institute
TNO Centre for Protein Technology	Wageningen Agricultural University	TNO Nutrition and Food Research Institute
TNO-TUE Centre for Building Research	Eindhoven University of Technology	TNO Building and Construction Research
TNO Centre for Ageing Research	Leiden University	TNO Prevention and Health

Table 2. TNO and the ICES-projects

#### Land-water-impulse

TNO Institute of Applied Geoscience

#### Biotechnological soil purification

TNO Institute of Environmental Sciences

#### High-performance computing and networking

TNO Physics and Electronics Laboratory

#### Transport technology

TNO Institute for Policy Studies

#### Agro-chain management

TNO Nutrition and Food Research Institute

#### Underground construction

TNO Building and Construction Research



TNO's involvement in European research programmes is vital to its strategic technology development. These are technologically challenging programmes with additional significance for TNO as they involve cooperation with companies and other research institutes. TNO is active within the framework of EUREKA (participating in 25 projects) and EUCLID (European Cooperation for the Long term In Defence), EUREKA's defence counterpart. In 1994 TNO participated in 20 of the 45 EUCLID projects. TNO also has broad involvement in the Fourth European Framework Programme (see table 3 for an overview).

### Cluster projects

Global competition demands of national economies that the limited means available for technological renewal should be utilized efficiently. This requires a policy in which government, industrial companies and R&D organizations work towards common objectives, each from its own mission. From this viewpoint, TNO defined proposals several years ago for establishing projects to reinforce the relationship between industry, government and TNO, with the objective of involving industrial companies at an earlier stage of technological development.

After a cautious beginning in 1993, these cluster projects received a major boost in 1994. Eight new projects were announced, and six of them were actually launched. These are strategic projects in which technologically advanced companies cooperate with R&D institutes.

The projects have high economic potential, good market opportunities and a clear message for other companies. The main objectives are to foster knowledge-intensive activities in the Netherlands, encourage cooperation between companies and R&D institutions and reinforce the knowledge base of organizations like TNO.

### Financial input

TNO's financial input may be divided into two: income from services rendered and products delivered, and government financing. Over the past few years revenues from contract research have increased continuously in absolute terms and relative to total income. Excluding contract research undertaken for the National Government, income has tripled in absolute terms and almost doubled in relative terms over the past 15 years.

TNO performs tasks of immediate social significance in a number of fields, varying from reinforcing the innovative capacity of society in the broadest sense to acting as an in-house laboratory for the

Ministry of Defence. Where social significance is high and private investments are in short supply, the government provides TNO with the financial resources to perform these tasks, many of which involve investing in knowledge development and technological exploration. TNO is financed by the government in two ways: basic financing and programme-related financing. Basic financing is intended to unlock new areas of knowledge and is on the budget of the Ministry of Education, Culture and Science whilst the allocation of programme-related financing is a matter of negotiation with the respective ministries, based on proposals submitted by TNO.

A breakdown of TNO turnover in 1994 is shown in table 4, which distinguishes between TNO sections active in industrial technology, defence research and health research; the last two sections have a different financing structure.

The figures for 1994 are influenced by a part of TNO's health research being transferred to TNO Nutrition and Food Research, resulting in a higher turnover from industrial technology activities.

Table 3. General overview of TNO's participation in the European Framework Programme in 1994

Sub-area	Number of projects
Energy technology	31
Environmental technology	29
Industrial technology	33
Life sciences	13
Information technology and telecommunications	12
Other	11

Table 4. Breakdown of TNO's turnover in 1994\* (in millions of Dutch guilders)

	Industrial technology		Defence research		Health research	
	1994	1993	1994	1993	1994	1993
Domestic and foreign contracts	292 (59.2%)	279 (58.2%)	25 (15.5%)	24 (15.4%)	26 (40.6%)	37 (36.7%)
Ministerial contracts	68 (13.7%)	71 (14.9%)	30 (18.5%)	24 (14.8%)	3 (4.7%)	8 (7.4%)
Government financing	134 (27.1%)	129 (26.9%)	107 (66.0%)	111 (69.8%)	35 (54.7%)	56 (55.9%)
Total	494 (100%)	479 (100%)	162 (100%)	159 (100%)	64 (100%)	101 (100%)

\* ) Not shown in this table is other turnover: in 1993 NLG 21 million, in 1994 NLG 25 million.

# Output

*In the contract research organization TNO, knowledge is the major product, whether processed as hardware, that is an apparatus, instrument, component or new material, or as software, a rapidly growing field.*

Knowledge is injected into new processes, methods or systems and recorded in recommendations and reports. In specific cases, TNO protects its knowledge by patent.

The principal share of TNO's output is the result of contract research, a generally confidential outcome. TNO also makes its knowledge and experience available to a wider audience by publications, presentations at congresses and through demonstrations, instruction and training. Where the knowledge generated by TNO is of strategic importance to the organization, it is added to the technology portfolio.

## Output linked to government financing

One major purpose of government financing is to support exploratory research projects. Accumulating knowledge for later utilization is vital. A small percentage is used to finance doctoral research, special knowledge-transfer projects and the exploration of new markets. A number of examples of government-funded projects that were successfully completed in 1994 are shown in table 5.

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*Table 5. Examples of projects successfully completed in 1994 with a high percentage of government funding*

### **TNO Metals Research Institute**

- Opportunities for applying stainless steel instead of galvanized steel in the construction sector in view of the new government requirement of a lifetime of at least fifty years.
- Applicability of welding additives with lowered breaking points to prevent construction segments to be welded from pre-heating
- Effects on the standard design approach of applying high breaking-point types of steel in shipbuilding

### **TNO Building and Construction Research**

- The COMBINE project, which may be viewed as the initial step en route to an intelligent, integrated building-design system.
- WISH, a computer program for calculating actual air flow and temperature distribution in buildings

### **TNO Institute of Applied Geoscience**

- The ATLAS project, intended to give the designer/constructor of large architectural constructions integrated access to the computer systems suppliers operate with
- FDEM project for defining specifications of a Frequency Domain Electromagnetic Multi-Receiver system for exploring shallow subsoil (0-50 m)
- Simulation of the heterogeneity of the geohydrological parameters for modelling substance transport in the subsoil

### **TNO Nutrition and Food Research Institute**

- In-vitro digestion research
- Embryo-transgenesis and signal-transduction in grains
- Chain management in the cattle-feed sector

### **TNO Prins Maurits Laboratory**

- Development of a testing method for detonation properties of mixtures of hydroperoxide, isopropanol and water
- Knowledge development in the field of missile combustion technology

### **TNO Institute of Environmental and Energy Technology**

- Evacuation of large groups of people in emergency situations
- Personal risks of inflammable coolants as substitutes for freons
- Development of new gas separation technology on the basis of membranes and absorbing liquids

### **TNO Institute of Environmental Sciences**

- Development of an analysis methodology for ascertaining the environmental effects of lanthanides
- Determination of the proportion of lead isotopes for confirming facts such as the origin of lead in washland grass and the origin and age of wine
- Development of a test for determining the toxicity of substances in their effects on a type of micro-organism in the soil.

### **TNO Human Factors Research Institute**

- Application of Virtual Environment in research into ergonomic aspects of the workplace
- Relationship between motion sickness (sea sickness) and energy consumption, i.e. psycho-motor task performance

### **TNO Physics and Electronics Laboratory**

- Teleman UKIS: development of a world modelling module for telerobotics such as Automatic Guided Vehicles
- Thin-film sensor for measuring the E-field for research on hyperthermics

### **TNO Institute for Policy Studies**

- Application of certain databases for defining regional economic profiles





### Contract research

In 1994 TNO again completed numerous projects for Dutch companies, the Dutch government and international clients.

This part of TNO's output is often confidential in nature. Since a number of examples will be discussed in more detail in 'TNO Toppers' (see pages 18 - 30), this section will be limited to several numeric indicators. Table 6 gives an overview of 1994 turnover derived from contract research.

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Table 6. TNO's turnover derived from contract research  
(in millions of Dutch guilders)

Segment	1994	1993	1992
Domestic	338	342	325
- Trade and industry	228	229	221
- Ministries	101	104	96
- Local authorities	9	9	8
Foreign	110	107	90
- Internat. organizations	27	26	20
- Other	83	81	70
Total	448	449	415

A breakdown of TNO's turnover derived from contract research for foreign clients is given in table 7.

Table 7. TNO's turnover from contract research  
for foreign clients

Region	1994	1993	1992
EU	45%	52%	53%
Europe (other)	10%	6%	7%
Canada, USA	12%	8%	8%
Japan	6%	7%	6%
Other countries	3%	3%	4%
Internat. organizations	24%	24%	22%
Total	110	107	90

(in millions of Dutch guilders)

### Fairs and exhibitions

Fairs and exhibitions were another forum in which TNO presented its product package and the results of its work in 1994. The major exhibitions in which TNO participated in 1994 are shown in table 8.

Table 8. TNO at fairs and exhibitions  
in 1994

<b>Hannover Messe Industrie, Hannover</b>	Conditions at work
<b>ITEC, The Hague</b>	Training and simulation
<b>CeBIT '94, Hannover</b>	Smart card security, driving simulator
<b>Het Instrument, Utrecht</b>	Inspection technology
<b>Macropak, Utrecht</b>	Glass packaging, intelligent packaging machine systems, packaged products inspection
<b>Telematica, Amsterdam</b>	Traffic and transport
<b>Farnborough, Farnborough</b>	Anti-noise
<b>Osates/Technomer, Brest</b>	Inspection technology
<b>Holland Offshore, Amsterdam</b>	Pulsation in pipelines, geo-energy, explosion safety
<b>SAE, Detroit</b>	Collision safety
<b>RSV, Munich</b>	Collision safety, vehicle dynamics
<b>Support 94, Utrecht</b>	Mobility aids for handicapped people
<b>VSK, Utrecht</b>	Heating, climate control
<b>Aquatech 94, Utrecht</b>	Geo-hydrology and geo-information, membrane technology, waste water treatment, continuous activated sludge
<b>Society of Toxicology, Seattle</b>	Toxicology
<b>Food Ingredients Japan, Tokyo</b>	Food
<b>Eurotox, Basel</b>	Toxicology
<b>Food Ingredients Europe, London</b>	PRO-Q Food, proteins, oven technology
<b>Explorisk, Ghent</b>	AutoReaGas™
<b>Ceramitec, Munich</b>	Ceramics, oven technology, Q-kill software
<b>Achema, Frankfurt</b>	Membrane technology, photocatalytic oxidation
<b>POLEKO, Poznan</b>	Environmental technology



### Special products

What TNO offers the market is a combination of knowledge and problem-solving skills. This combination sometimes takes shape in a tangible product marketed by TNO. This is particularly true of software packages. Table 9 includes some of the major TNO products marketed on a commercial basis over the past year.



Table 9. Special TNO products

#### **MADYMO**

(crash victim simulation program), leased particularly by car manufacturers

#### **DIANA**

(elaborate software package based on a finite-element method for strength analysis and related problems), marketed by DIANA Analysis BV with seven new licences issued in 1994 (two in South Korea, one in Japan, one in Australia, one in Belgium, two in the Netherlands)

#### **FDPS-4**

(Foundation Pile Diagnostics System), 24 new systems sold in 13 countries in 1994, 94 total users globally in late 1994

#### **REGISPRO**

(REGional Geohydrological Information System), six licences issued in 1994

#### **OLGA**

(on-line groundwater database), five new subscriptions sold in 1994

#### **PRO-Q Food**

(software package for introducing and managing quality-control systems in the food sector), successfully marketed in 1994 by Computerplan BV; English-language version in preparation

#### **AutoReaGas™**

(computer program for calculating the effects of gas-cloud explosions), two copies sold in 1994

#### **TNO stereo test,**

one licence in 1994

#### **Working conditions software,**

500 copies sold in 1994, current total: 1,000

#### **EFFECTS**

(software package for calculating the effects of the release of hazardous substances), thirty copies sold in 1994; total in late 1994: 300

#### **SEABEL-2**

(software package for decision-making support in the event of environmental disasters at sea), one licence in 1994; successor to SEABEL-1 (ten licences issued)

#### **ALARMBEL**

(software package for automatic distribution of messages in incident rooms during emergencies), one licence in 1994

#### **CYCLE TEMPO**

(software package for calculating dynamic properties of thermodynamic cyclical processes), one licence in 1994 in addition to ten existing ones

#### **MILIS**

(software package: emission database and distribution model, particularly for local government policy in the field of air pollution)

#### **Plumeplus**

(software package: air pollution distribution model, particularly for granting permits)

#### **CAR**

(software package for calculating air pollution in the city at street level)

#### **Confocade**

(Laser Scan Microscope), twenty-five sold by the U.S. company Noran.

# TNO toppers

## 18 Océ 940 awarded prize

Océ, which markets folding machines for technical plans in addition to copiers, printers and plotters, has developed an elaborate on-line machine for the large-volume market segment. In the low-volume and medium-volume segments there was a need for a smaller, off-line machine.

The project assigned to TNO was to complete the development of a wide-format folding system and prepare the system for production. The project was organized around the basic model submitted by Océ, and its limits were set by the fixed cost price. Aimed at the central reproductive departments of small companies as well as the design departments and other departments of large companies (companies with decentralized organizations), the new Océ 940 off-line folding machine is easy to operate, occupies little space and can fold both DIN and other formats. TNO's role included designing a number of unique components, preparing the production plans, developing hardware and software, maintaining a dialogue with the suppliers, assembling the first engineering prototypes and carrying out the required inspections and quality control. Initial sales are highly satisfactory and users enthusiastic. The Océ 940 design earned an iF Design Award, which was presented during the 1995 Hannover Messe.

The folding machine was completed as part of a special programme initiated by the Ministry of Economic Affairs and intended to stimulate cooperation between large companies and the knowledge infrastructure in the Netherlands. (TNO Product Centre, Océ)



*TNO has made a substantial contribution to the development of a wide format folding system for charts and technical drawings, the Océ 940.*

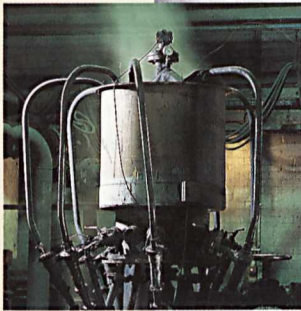
## Hydrogen creep tests

The petrochemical industry is always attempting to improve the efficiency of reactions by increasing the process pressure and temperature, and processes involving hydrogen are no exception. The combination of these three factors imposes special demands on the materials that make up the installations. TNO is one of the few institutions around the world that perform materials research in this particular field.

One important question petrochemists must answer is: 'How does hydrogen (used for cracking and hydrogenating) affect the strength of installations?' The difficulty posed by hydrogen is that the gas may form methane with the carbon present in steel. This may produce extremely high pressure at certain points, which may in turn cause cracking. The strength is also adversely affected in that this process causes carbon to disappear from the material, a phenomenon referred to as 'Nelson-hydrogen

corrosion'. This type of corrosion occurs in materials with a ferritic structure. Installations involving hydrogen under high pressure are currently operated at a temperature determined by the breaking point of the types of steel used. Higher temperatures are, however, considered desirable and working with them will require a solution to the phenomenon called 'creep' to be found. Creep has been extensively researched, as has the effect of hydrogen on the material. The combination of the two, however, remains largely unexplored. TNO researchers are now among the first research groups to succeed in actually performing creep tests in a hydrogen environment (maximum H pressure: 200 bar, maximum temperature: 700°C). Research is currently focusing on the behaviour of a new martensitic chromium steel that is expected to show considerable resistance to hydrogen corrosion as well as a high creep strength.

(TNO Metals Research Institute)



### Pyrohydrolysis for waste containing zinc

Steel producers around the globe are looking for a technically and economically acceptable solution to the problem of processing waste containing high concentrations of zinc as well as other metals such as lead and cadmium. Hoogovens IJmuiden submitted the problem to TNO.



TNO has developed an isolation method based on pyrohydrolysis for two major waste flows: blast-furnace dust and oxygen converter scrubber sludge. The method involves heating the waste in a hydrochloric atmosphere to a temperature of around 825°C. This results in volatile metal chlorides that are removed from the reactor to condense. Encouraging laboratory results have justified continuation of the research on a semi-continuous scale in a pilot plant fluid-bed system.

*(TNO Institute of Environmental and Energy Technology)*

*Various steps in the processing of blast furnace dust at Hoogovens IJmuiden.*

### A vehicle behaviour database

Car manufacturers take particular interest in the quality of the products made by their competitors. Suppliers are equally eager to learn how new models developed by clients perform. Together these facts indicate a growing need for information on dynamic vehicle behaviour. In 1994, TNO completed a sophisticated database system that stores and makes available (for a fee) such information on passenger cars.

Its broad experience in the field of vehicle dynamics and its independent position make TNO exceptionally qualified to develop and operate this type of database. This arrangement is made attractive to the client by four quality aspects: high-quality data at a relatively low price, the continuous addition of information on new models, the facility of the simple insertion of special requirements into the system, and the option of expansion involving user-supplied information.

TNO's data source is a series of the following driving tests in conformity with ISO standards:

- steady state circular test;
- random steering input test;
- braking in turn test;
- cross wind behaviour test;
- severe lane change manoeuvre;
- power off reaction test;
- step steer input test;
- straight line braking.

A presentation module has been attached to the database system. The package operates on MS-DOS personal computers.

*(TNO Road-Vehicles Research Institute)*

### Neural networks contribute to clearer picture of subsurface

TNO has cooperated with its Norwegian sister organization SINTEF to develop a new and revolutionary computer program for supporting seismic research into hydrocarbon reservoirs.

Geoprobe provides new tools to describe reservoirs more accurately. These tools were developed to correlate three-dimensional seismic information with reservoir characteristics derived from exploratory drilling. Neural networks are one of several tools relied upon for interpreting data. The package also includes modules for processing and simulating data. Geoprobe was developed for UNIX work stations.

The system became available in mid 1994, and extensive tests were subsequently commenced. In Germany, gas reservoirs (Rotliegend) were analysed, and in the Middle East, 'labyrinth-type reservoirs'. Researchers and sponsors have expressed their great satisfaction with the impressive results. Financial support for the project was provided by the Saudi Arabian Oil Company, the German oil and gas producer Erdöl und Erdgas GmbH (BEB), IBM and High Tech Automation, as well as the EU and the Norwegian Council for Scientific Research. A commercialization scheme for Geoprobe is currently being set up.

*(TNO Institute of Applied Geoscience, SINTEF)*

*The new TNO database on vehicle behaviour includes information on cross wind behaviour. TNO has also developed a tilt-monitoring system, which has proved to be an extremely useful tool in helping truck drivers to keep their vehicle stable.*



### **TNO scent strip in global pursuit of codling moth**

The codling moth is a dreaded pest and a very serious problem in apple and pear orchards around the world. The need for an effective, durable and environmentally safe control method is urgent. Now TNO technology has brought one within reach.

Large-scale attempts have been undertaken for many years to control the codling moth with chemical insecticides. However, insect resistance is becoming much stronger. An exceptionally environmentally friendly technique for controlling insects without inducing resistance involves the use of natural substances, pheromones, which insects use to communicate with each other. For the codling moth the natural sex

pheromone that female insects use to attract males is known. When this substance is used in orchards, the male insects are misled and are no longer able to find females, thus causing reproduction to stop.

Pheromones are complex and relatively expensive substances, but owing to their extremely high activity rate, only small quantities are needed. The trick is to formulate them so that appropriate dosages are released over an extended period of time up to several months. TNO has developed a controlled-release system that can be adjusted to a wide variety of pheromones.

In 1994 the US company Trécé, global market leader in insect monitoring systems, decided to license the TNO technology for orchard applications. Large-scale testing of TNO scent strips started immediately in a number of major fruit-producing countries and the results were excellent in every case. Marketing of the strips will start in 1995 and Trécé expects to extend the application of this technology to other pest insects.

*(TNO Plastics and Rubber Research Institute/Branch-specific Research Centres)*

### **TNO pioneers interactive battle simulation in Europe**

In crisis management operations success in the event of confrontation depends heavily on preparation. Simulation is by far the best means to increase the benefits of exercises through lower costs and greater flexibility. Where simulation is applied, equipment does not wear, fuel is not consumed, nature is not harmed and participants run no risks. Finally, events are proving simulation to be a highly effective means for developing and evaluating new military theories and new resources and technology.

The U.S. Defense Department has elevated the technology of linking simulators to the forefront of its policy. Distributed Interactive Simulation (DIS) protocols allow participant simulators to operate with complete autonomy; only relevant information is exchanged via a cable network. The result is that crews in the simulators interact with each other. Simulators can be employed correctly when the criteria exist to experience highly dangerous conditions, rapid orientation and response in an unknown environment and team operation throughout. TNO has performed several demonstration projects for the Ministry of Defence which involved linking simulators from different suppliers to each other.

DIS is a breakthrough in simulator use and utilization for military applications. Since telecommunications connections make DIS basically independent of location, existing training infrastructure equipped with simulators can be utilized more broadly and more completely. One example is the possibility of preparing international peace-keeping operations in realistic conditions involving weapons systems from different countries and a range of military services, or even the soldiers who will actually execute the operations, if desired. The sequence of events can be analysed at all times from a variety of perspectives.

Supported by the Royal Dutch Army, TNO is pioneering the introduction of this technology in the Netherlands. Equipped with simulators, a large number of Dutch and foreign manufacturers and research institutes participated in the DIS demonstrations coordinated by TNO during the ITEC Conference held in 1994. TNO used a tank simulator to participate in an electronic battle simulated from Orlando, Florida. One major result of



this cooperation is that it makes top expertise available to business.

*(TNO Physics and Electronics Laboratory)*

### **LIQUI-FLOW: big in small flows**

Bronkhorst High Tech BV specializes in mass-flow and pressure sensors. Their ambition to be at the forefront of technology is producing impressive growth figures, part of which come from a mass-flow meter, a product developed with TNO and a growth factor since 1994. The meter is called LIQUI-FLOW and is capable of measuring extremely small mass transports in liquids. Two versions exist, one for the 2-100 grammes per hour range, the other for the 50-1000 grammes per hour range.

Initially developed for various types of laboratory applications, LIQUI-FLOW is highly sensitive. Potential users were not slow to discover its excellent performance in the processing industry: one cattle-feed producer now applies it to add enzymes and other micro-nutrients to the feed. LIQUI-FLOW is equally suitable for the creation of a very even mixture of air and diesel fuel, or to monitor the cool-water circuits of nuclear reactors, quantities of artificial odours or flavourings, or scented paper. Obviously, the applications are numerous and multifaceted.

LIQUI-FLOW applies two 'ancient' physical concepts: measuring mass flows by thermal effects, and applying a thermopile to detect small temperature differences. The combination of these two concepts as proposed by TNO was what solved Bronkhorst's difficulties in developing a flow meter for small liquid-mass flows. TNO's extensive experience in thermopile applications and in temperature distribution simulations in

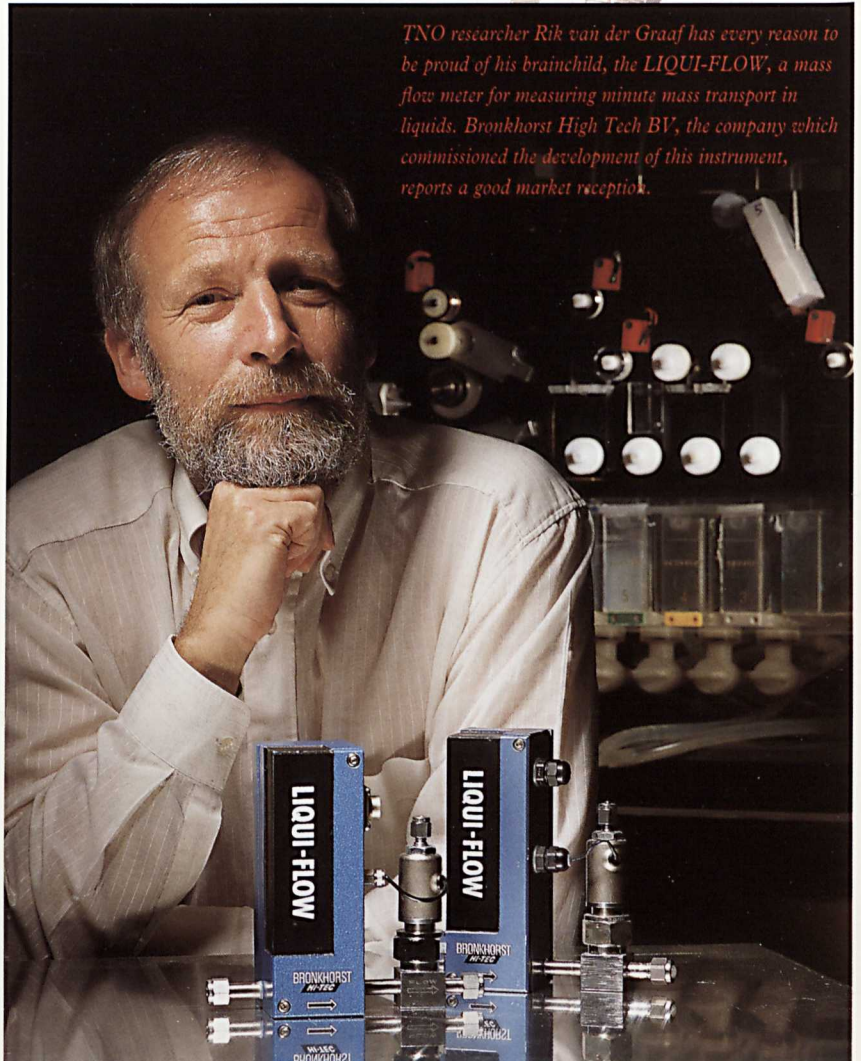
flowing media was put to excellent use in subsequent development.

A close partnership has developed between the TNO division involved and its client in which TNO operates as an advance guard of the Bronkhorst R&D department. That makes TNO feel equally responsible for the challenges that Bronkhorst faces, something which is stimulating in practice.

*(TNO Institute of Applied Physics Bronkhorst High Tech BV)*

### **Cleaner steel production in Poland**

It is a well-known fact that for the Netherlands it is often much more effective to make environmental investments abroad, such as in Eastern Europe. Plants like the steel factory in Huta Ostrowiec, Poland, cause a lot of air pollution. TNO has been closely involved in a project designed to reduce the emission of pollutants from this particular industrial complex.



*TNO researcher Rik van der Graaf has every reason to be proud of his brainchild, the LIQUI-FLOW, a mass flow meter for measuring minute mass transport in liquids. Bronkhorst High Tech BV, the company which commissioned the development of this instrument, reports a good market reception.*

In 1992, the Dutch Ministry of Housing, Physical Planning and the Environment commissioned TNO to define a clean-up plan for the Huta Ostrowiec Steel Factories. TNO's partners in the project were Hoogovens and the Technical University of Warsaw. In September 1994, the plans and recommendations were presented. The major recommendations were:

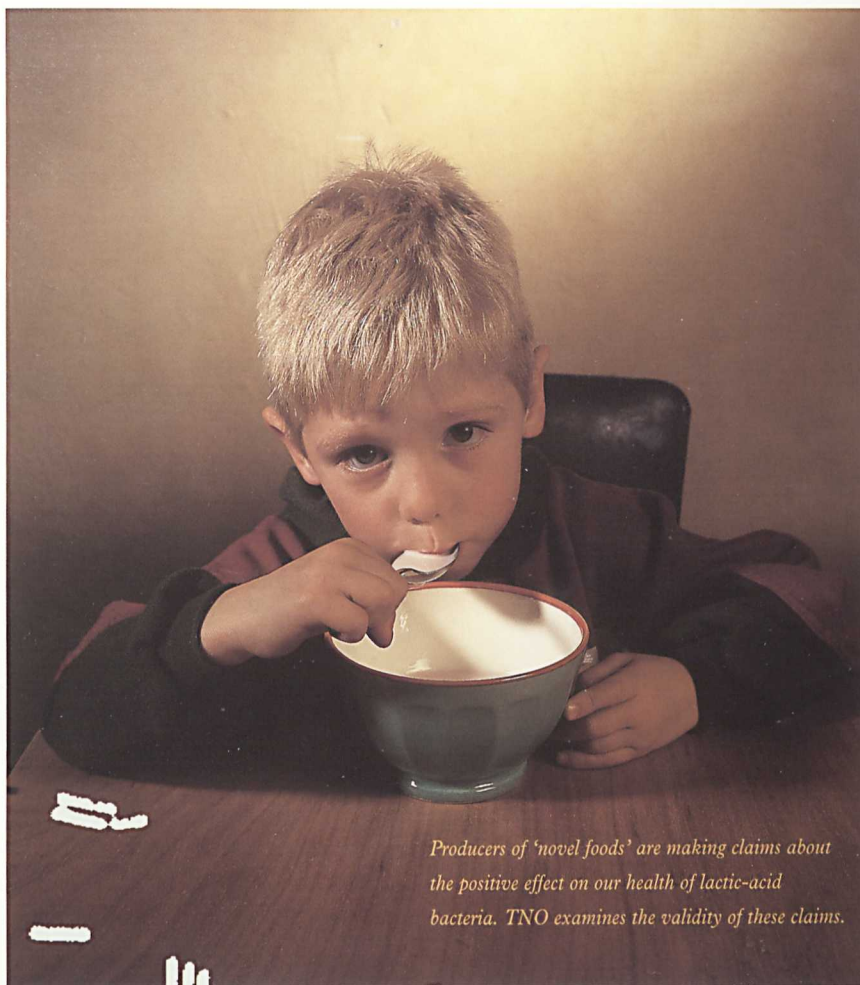
- the installation of an antidust system for the melting furnaces;
- the reduction of sulphur emissions by switching to a fuel mix with low-sulphur components;
- the taking of various measures related to water treatment, most of which had a break-even period of less than two years;
- the taking of various measures related to the prevention, re-use and useful application of waste;
- the taking of measures to prevent hazardous waste or, if prevention is impossible, to isolate hazardous waste;
- the selection of a new waste disposal site.

By the time the Master Plan was being completed, many of these recommendations had already been implemented.

*(Hoogovens, Technical University of Warsaw, TNO Institute of Environmental Sciences, TNO Institute of Environmental and Energy Technology, TNO Institute of Applied Geoscience)*

### How healthy are lactic-acid bacteria?

The relationship between diet and health is a matter of particular importance to the modern consumer. Manufacturers, responding to this trend, are introducing new products with added properties conducive to health. This trend is



*Producers of 'novel foods' are making claims about the positive effect on our health of lactic-acid bacteria. TNO examines the validity of these claims.*

particularly discernible in dairy products, where fermented milk products are the foundation of a fast-growing range.

Some lactic-acid bacteria, including certain types of *Lactobacillus* and *Bifidobacterium*, used in preparing dairy products, are said to encourage good health by protecting against harmful bacteria. In addition, such claims state that they produce substances that affect the intestinal system in a positive way, in particular by stimulating the immune system. Many of these claims have yet to be adequately substantiated.

A number of TNO research groups are active in the field of lactic-acid bacteria. They have tested the effectiveness of some of the 'novel' and 'healthy' foods marketed over the past two years, focusing on the alleged positive effect of

these micro-organisms. Finally, TNO is researching the production by *Lactobacillus* of compounds with antibacterial activity against major food-spoilers or food pathogens such as *Listeria* and *Clostridium*.

Bifidobacteria research made a breakthrough in 1994 when a method was developed to genetically modify these organisms such that new possibilities of researching and applying these major intestinal bacteria were brought within reach.

TNO also occupies a prominent position using lactic-acid bacteria as a vaccine carrier, particularly for applications in the Third World and in animal health care.

*(TNO Nutrition and Food Research Institute, TNO Prevention and Health)*



### Blood vessels formed in culture help rheumatism researchers

Do aberrant tissue repair processes contribute to rheumatism? Do they cause joint immobilization and pain in rheumatoid arthritis or worsen joint damage? These are the questions the Ministry of Health, Welfare and Sports submitted to TNO.

Why TNO? Our organization has unique expertise in the field of research on fibrin housekeeping and human endothelium cells in vitro. Endothelium cells form the inner lining of blood vessels whilst fibrin is a protein essential to blood clotting. Both are important for tissue repair. Research has commenced on the relationship between fibrin lining in the

joint and the growth of new blood vessels and the characteristic symptoms of rheumatism. The processes that contribute to joint deterioration are, however, difficult to evaluate directly in patients. The natural alternative is testing in animals, but processes specific to humans are involved in growth and leakage of blood vessels. These considerations prompted the choice of cell culture experimentation, which has the additional advantage of sparing experimental animals.

The TNO researchers discovered in which specific conditions human endothelium cells from micro blood vessels can be encouraged to form new blood vessels in culture. Work has now progressed to the point that these efforts are successful

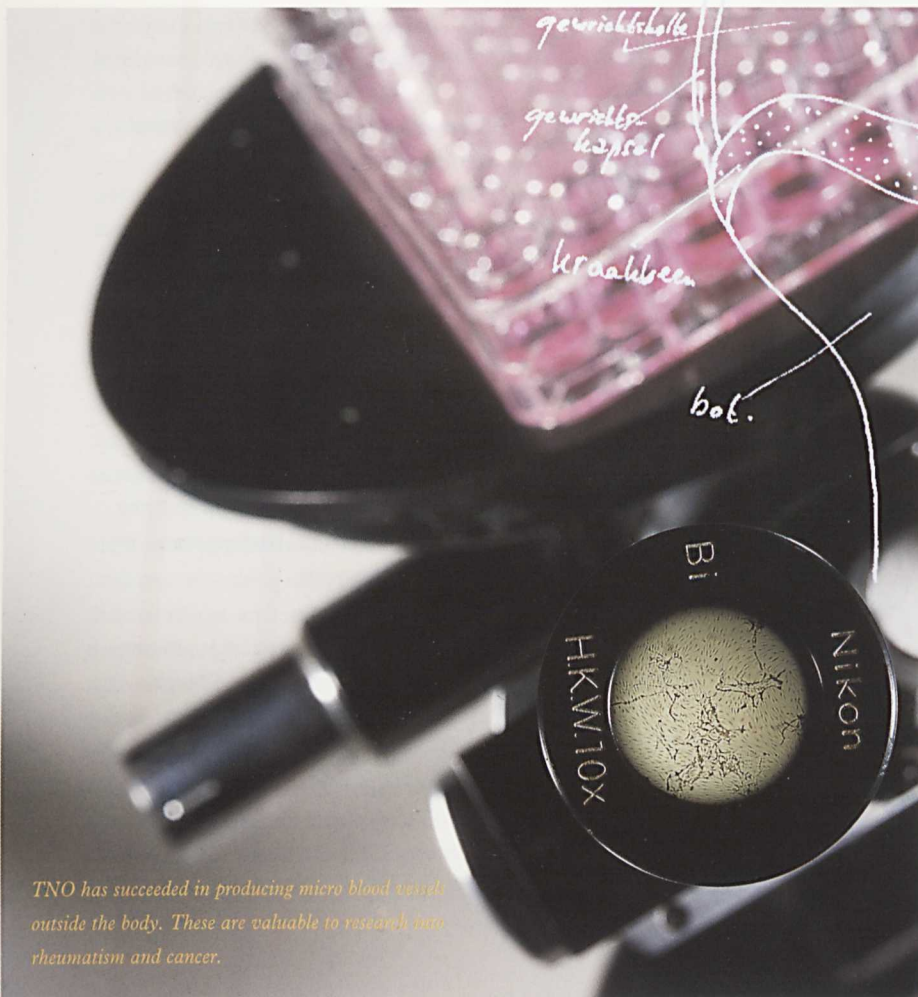
with a mixture of growth factors and cytokines and with joint fluid from severely affected patients. In culture the processes can be analysed and influenced, and the substances that retard or stimulate the process can be tested. This allows specific factors to be traced that are involved in the growth of blood vessels (angiogenesis) in the rheumatoid arthritis. Angiogenesis has harmful consequences not only regarding rheumatism, but also with respect to tumour growth and diabetes (retina affected). The mechanism is, however, essential in processes such as wound healing and restoration of blood circulation. The pharmaceutical industry is showing increasing interest in these new research opportunities.

*(TNO Prevention and Health)*

### Biotechnology no extra threat to farmers' freedom

Slowly but surely, modern biotechnology is taking on practical significance for agro-food chains. Past studies have suggested that new biotechnology is putting farmers under pressure because they are becoming more and more dependent on the seed and processing industries. TNO's STB Centre for Technology and Policy Studies has analysed this trend in cooperation with the Agricultural Economic Institute (LEI). Supported by the Technological Assessment Programme of the Ministry of Agriculture, Nature Management and Fisheries, TNO and LEI have examined how modern biotechnology affects the vertical relationships in agro-food chains. Is it reasonable to expect entirely new chains of supply, production and processing in the future? What will be the farmer's position?

TNO, which was involved in the study because of its expertise in the field of sector studies and biotechnology, used an entirely new methodology to chart



*TNO has succeeded in producing micro blood vessels outside the body. These are valuable to research into rheumatism and cancer.*

biotechnology for each of the nineteen agro-food chains. Two chains were subsequently selected for more detailed examination: the consumer potato chain and the dairy chain.

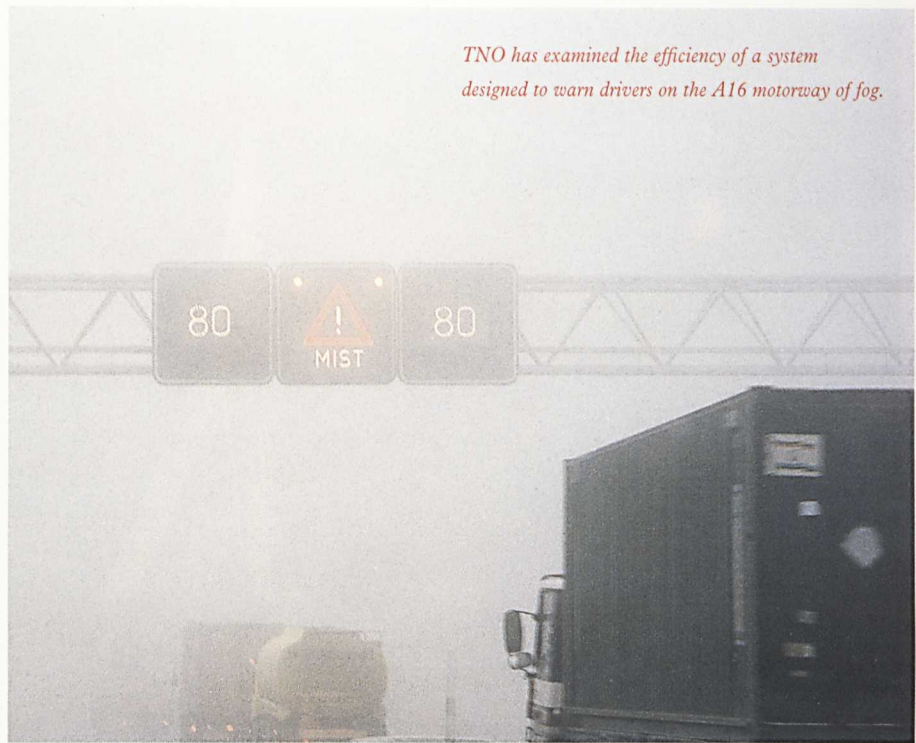
The major result of the TNO-LEI study is the conclusion that new biotechnology has been of only minor importance in the changes which have been taking place in the vertical relationships within the two chains. At most, new biotechnology accentuates changes prompted by internationalization, growing retail influence, concentration and expansion. A second conclusion is that the success of products made possible by the new technology largely depends on the degree of social acceptance companies achieve for their products. Previous predictions that biotechnology would reduce the farmer to the lack of business could not be confirmed. Where this does happen, it is caused by other developments.

*(TNO Institute for Policy Studies)*

### **A16 fog system raises traffic safety**

On 6 November 1990, there was a catastrophic traffic accident on the A16 motorway in the Netherlands. In the treacherous fog about 100 vehicles were involved in collisions. This prompted the Ministry of Transport to instal a warning system on this route to advise motorists to decrease speed when visibility is low. TNO has analysed the effects of the system on driving behaviour. The fog system consists of a number of fog sensors and warning devices. Twenty fog sensors continuously measure visibility over a thirteen-kilometre route. In thick fog the system displays the maximum speed on overhead matrix systems on the motorway, in addition to a fog warning.

Commissioned by the Ministry of Transport, TNO conducted an



*TNO has examined the efficiency of a system designed to warn drivers on the A16 motorway of fog.*

evaluation of the system, operative since October 1991, over a period of two years. The evaluation included analysis of traffic data at the individual vehicle level in its relationship to exact visibility data on site and to the images displayed above the motorway.

TNO's conclusion is that the fog system has favourable effects on driving behaviour. In foggy conditions average speed is substantially lower on road sections with a fog system than on sections lacking one. Speed distribution also decreases, as does the difference in speed between the right and left lanes. The favourable effect is most clearly illustrated by the accident data, which shows that since the second year after the introduction of the system there have been no more fog accidents on the road section protected by the system, unlike on other motorways in the same area.

TNO has already applied the expertise acquired in this project on driving behaviour and fog to great benefit in European projects concentrating on the development of the application of telematics in traffic.

*(TNO Human Factors Research Institute)*

### **Dynamic testing of infantry's anti-tank missile system**

The TOW anti-tank guided-weapons system is one of the major anti-armour weapons in the Royal Dutch Army. TOW stands for Tube-launched, Optically-tracked and Wire-guided and refers to firing, target-tracking and missile-guiding methods. The Army was eager to know what effects the new TOW 2A anti-tank missile system has on a target in realistic conditions. For that purpose TNO has designed and built a testing range unique in Europe.

An anti-tank missile works on the basis of the detonation of a 'hollow charge', and its effectiveness is dramatically reduced by Explosive Reactive Armour (ERP), a system made of small metal compartments the size of a cigarette packet, attached to surface of the tank. The compartments contain an explosive charge that causes the particle beam from the anti-tank missile to be dispersed before it pierces the armour.

The TOW 2A, a TOW missile with a double charge, was developed in response to the ERP. The primary hollow charge in the



*DIANA, a finite-element computer program developed by TNO, was used for strength analysis in designing the Rotterdam Erasmus bridge.*

### **Renewal in Rotterdam with DIANA's assistance**

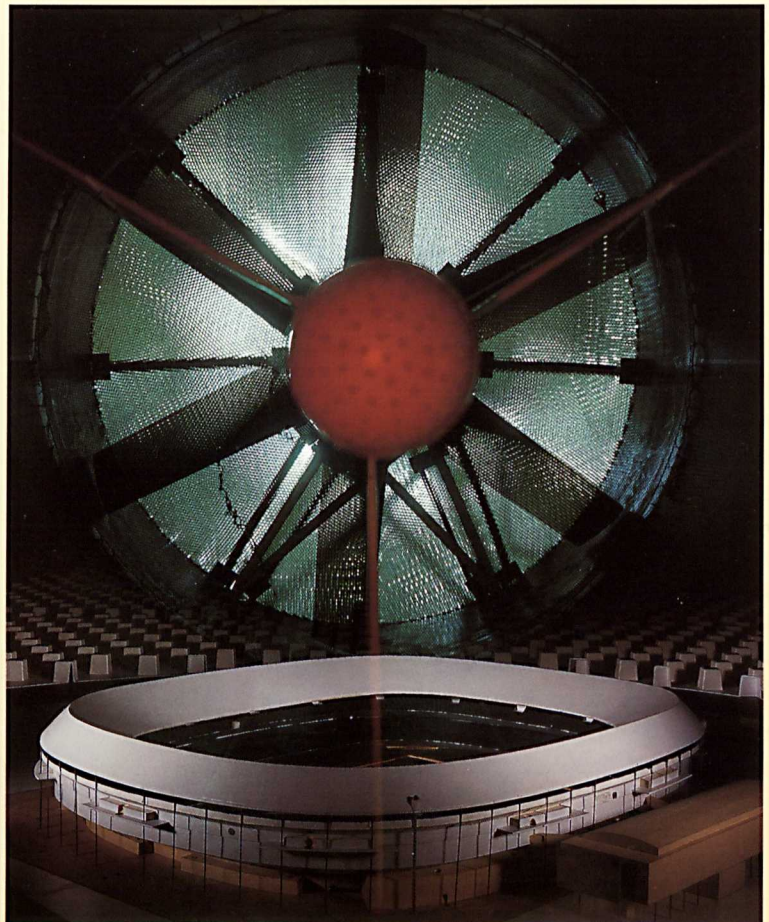
In Rotterdam, renewal is natural: the Feyenoord Stadium and the Erasmus Bridge are just two examples of this from 1994.

DIANA, a computer program developed by TNO, was an indispensable aid. For the stadium project TNO performed wind tunnel research as well.

DIANA has become a household word in the world of architects and builders. It is a software package based on the finite-element method, a mathematical technique for solving problems which recur frequently in many different forms in TNO's daily work: from the strength of a drilling platform to the heat flow during vulcanization of rubber.

*(TNO Building and Construction Research  
TNO Institute of Environmental and Energy  
Technology)*

*The Rotterdam Feyenoord stadium in the TNO wind tunnel, to assess among other things whether the new roof is sufficiently storm-resistant. DIANA proved indispensable in the design of the free-standing space framework.*



tip neutralizes the explosive compartment of the ERP armour. Several microseconds later the secondary hollow charge is detonated; it subsequently pierces the armour.

Instrumented testing of the TOW 2A presented difficulties which may only be summarized here. Up until last year, anti-tank missiles were tested statically, which means that the charge was detonated about a metre away from the target. Real situations are, however, dynamic: the missile proceeds towards the target at a certain speed. So TNO built a facility for dynamic anti-tank missile testing. In the tests conducted there, the missile is launched with a gas cannon and guided into the bunker via a thirty-metre long tube. There it is detonated. The exact sequence of events during the explosion can be traced. To accomplish that goal, equipment including four high-powered X-ray flashes was installed to record consecutive images of what happens behind the smoke. In 1994, four tests were carried out.

*(TNO Prins Maurits Laboratory)*

### Safety first in new ferry

The safety of ferries has been a controversial subject for years, and TNO has reason to doubt the effectiveness of the requirements defined by the International Maritime Organization (IMO) for this type of ship. Inspired by Ernst Vossnack, former head of the design department at Nedlloyd, TNO recommendations on increasing safety have been applied to a new ferry for the Holwerd-Ameland line.

How a ferry takes on water subsequent to a collision is vital to safety analyses. The specific construction of ferries causes them to tend to capsize if a hold or an engine room fills with water. A ferry with an entire car deck under water is highly unstable, but current regulations

presuppose that such water will enter the ship gradually and thus prevent such a degree of instability. TNO finds this presumption contentious. Researchers have successfully used computer simulations to demonstrate that the process of water entering the ship is clearly dynamic in nature. Incoming water will not immediately spread equally over the compartment, so the design of the ship must allow for a shifting centre of gravity. This shifting will cause a rolling motion potentially putting the ship in a more dangerous situation in which capsizing is a distinct possibility.



*A new safety philosophy has been employed in the new ferryboat 'De Sier', now operating in the Waddenzee off the coast of the Netherlands.*

Shipowner Wagenborg, which runs the service between Holwerd and Ameland, was challenged by these considerations and acted on the recommendations, which required measures such as filling the 2.2 m void between the inner and outer shell of the double ship wall with foam blocks. This prevents water from entering the ship when damage occurs and also contributes to the absorption of kinetic energy released during a collision. The preceding experimental research, which dealt with fire safety as well, was supported by a number of Dutch shipowners, two classification agencies and the Dutch government. The new ferry, *De Sier*, is now in operation in the Waddenzee off the coast of the Netherlands.

*(TNO Building and Construction Research, Ernst Vossnack)*

### Computer assists the production of safe food

From 1 January 1996, food companies in the European Union will be required to ensure the food safety of their products by operating in conformity with the 'HACCP methodology' (Hazard Analysis Critical Control Points). TNO has developed a software program for this purpose. It is known as 'PRO-Q FOOD' and it assists companies in developing, implementing and maintaining a process management plan in conformity with this method.

The HACCP methodology was developed in the United States in the 1960s in order to produce safe food for astronauts. It subsequently spread to other branches of the food and beverages industry. The EU is currently conforming to the recommendations made by the UN Codex Alimentarius.

A second factor behind the harmonization of food safety legislation is the change in consumer attitudes

towards food and in the rise of new food products.

28 PRO-Q FOOD 2.0, the software package developed by TNO in 1994, is intended for company officials responsible for developing and maintaining quality systems which currently focus on managing health risks related to food production. European and related Dutch regulations explain why this computer resource, marketed by Computerplan BV in Delft, is selling briskly. Success in the domestic market has convinced Computerplan that an attractive market must exist for an English-language version. First on the list: the United States and Canada.

*(TNO Nutrition and Food Research Institute, Computerplan BV)*

### Refrigerator cooling by air instead of CFCs

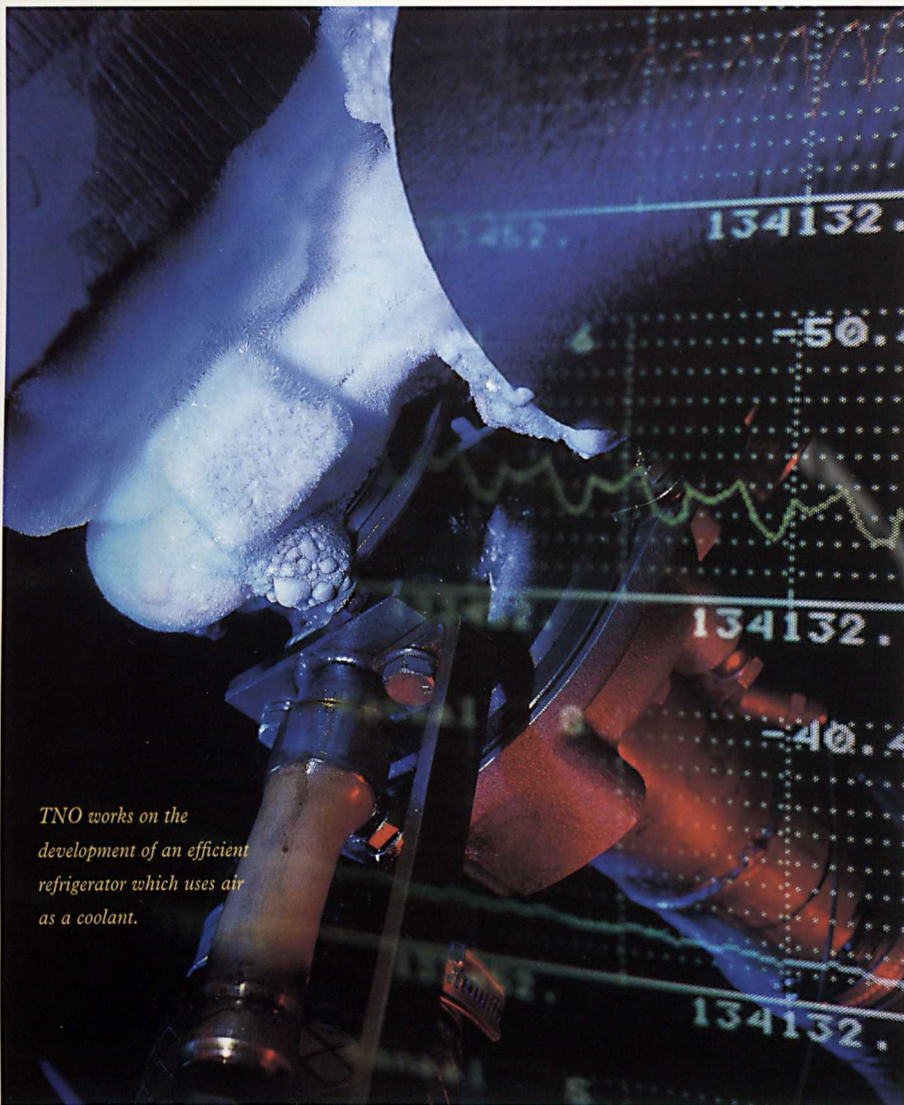
There is a global curfew on CFCs to reduce the deterioration of the ozone layer. Dozens of applications now require alternatives - such as refrigerators, in which CFCs and HCFCs were prized coolants until recent times. TNO has taken the initiative for further international development of the air-cycle concept, an alternative that uses air as a coolant. The Air-Cycle Pilot Plant was completed in TNO's Apeldoorn complex in late 1994 to optimize the concept so that it can compete on an economic level with existing vapour-compression machines. This project is part of the European JOULE II programme, which involves partners from England, Scotland, Ireland and

Germany, each supported by companies from their respective country. TNO's pilot plant has since proven that the concept is practicable and has a number of additional advantages. The results are so attractive that TNO is now working with refrigeration companies towards the commercialization and market introduction of refrigerators and heat pumps based on the air-cycle concept. *(TNO Institute of Environmental and Energy Technology)*

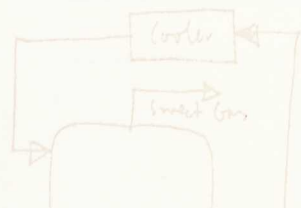
### Making front ends safer for pedestrians

In most European countries, a considerable percentage of traffic injuries are suffered by unprotected people: besides cyclists, mostly pedestrians. One way to improve this situation is to modify the front end of passenger cars. TNO has made a major contribution to future European legislation in this area. In the early 1980s, the European Experimental Vehicles Committee (EEVC) created a working group to research the issue of unprotected traffic victims in more detail. The main purpose statement was 'to develop standards for the level of injury acceptable in the event of a collision involving a pedestrian and the front end of a car, and to indicate how front ends should be tested'. Essentially, that testing was to involve the bumper and the front edge and upper surface of the bonnet.

In 1994 the EEVC submitted a proposal on how safety aspects of passenger cars could and should be evaluated on this point, based on injury standards for the effects of a collision on the legs and head of a pedestrian. The working group indicated how the dummies used for testing should look. Initial testing programmes have since demonstrated the problems and possibilities for designers of new passenger cars in satisfying the standards proposed by the EEVC. In any



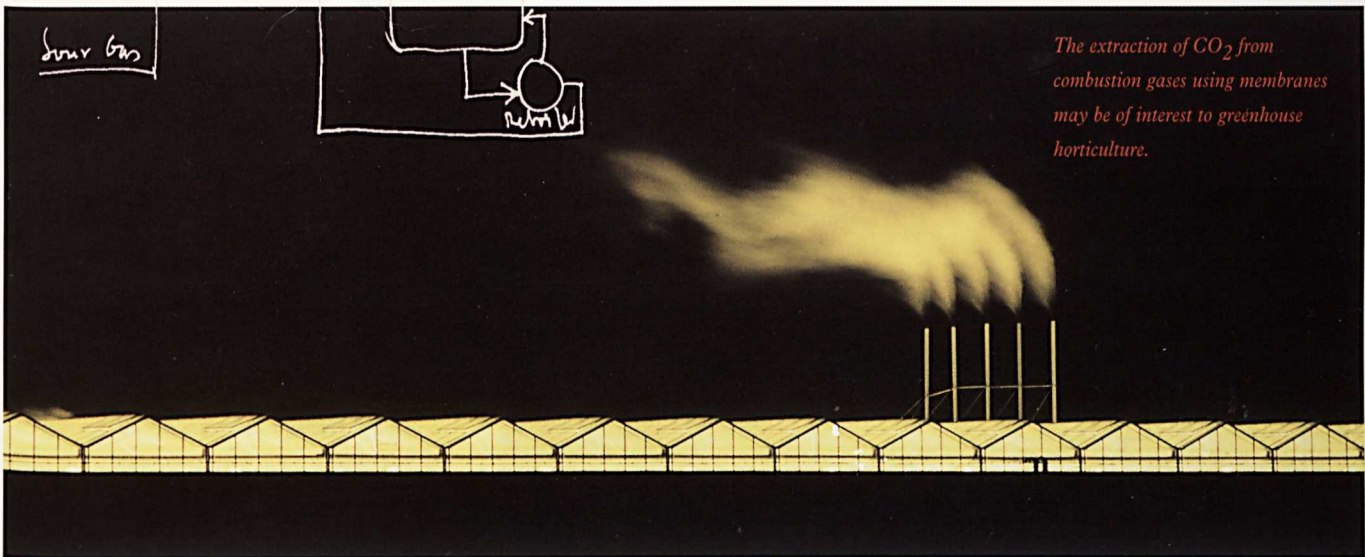
*TNO works on the development of an efficient refrigerator which uses air as a coolant.*



case, the requirements should be considered at the earliest possible stage of design. TNO has been a major contributor to the development of the new standards. The standards are, however, not expected to

carbon dioxide from the combustion gases is an attractive means of limiting emissions, for economic and other reasons. In 1994 TNO, commissioned by a Norwegian oil and gas consortium, began researching the possibility of applying

summer. Furthermore, carbon dioxide obtained via this method is contaminated with gases that inhibit growth. In 1994 TNO made a feasibility study involving the membrane technology developed by TNO and its potential combination with large-



*The extraction of CO<sub>2</sub> from combustion gases using membranes may be of interest to greenhouse horticulture.*

be incorporated into legislation before 1998. In anticipation of this, TNO is now performing tests required by manufacturers to determine the status of current vehicles. Other manufacturers are already allowing for the proposed regulations as they develop new models. TNO advises these car manufacturers on how to optimize car front ends using tools like the MADYMO software package. Additionally, TNO develops and supplies required testing equipment.

*(TNO Road-Vehicles Research Institute)*

**Carbon dioxide separation by membrane technology**

To prevent unwanted climate changes, many countries are attempting to limit carbon-dioxide emissions. A wide range of measures has been focused on reducing fossil-fuel consumption in one way or another. In some cases isolating

membrane technology in large-scale isolation. The isolated carbon dioxide could be injected into empty gas fields or used in the oil extraction process. The membrane gas absorption technology developed by TNO has already been demonstrated in the isolation of sulphur dioxide from flue gas (the principle: hollow fibre membranes are an efficient contact apparatus for separating a gas phase and a liquid phase in which the gas is selectively absorbed).

Elegant application can be made of the same technology in greenhouse horticulture, in which the link between high carbon-dioxide concentration and high plant growth has been applied for some time. The gas is, however, being produced via combustion of natural gas. This is clearly an unsatisfactory situation since it causes demand for gas to be high when demand for energy is low: in the

scale (STEG units) and small-scale heat and power plants (Gasmotor). The first option is already competitive, the second only when the annuity factors are low.

*(TNO Institute of Environmental and Energy Technology)*

**REGISPRO brings active soil management within reach**

In active soil management one has to deal with huge and varied amounts of data. TNO has developed an information system which not only facilitates the management and use of this data, but also brings it to a higher and more integrated level.

The geoscientific information system REGISPRO contains information about groundwater systems, soil quality and many other aspects associated with water systems. It offers special database

facilities and functionality for specific subsoil data in addition to advanced GIS functionality.

30 REGISPRO has proved to be a valuable tool in soil management and soil remediation. Most soil remediation projects are time-consuming. Large amounts of data become available: environmental, administrative, geological, soil-scientific, soil-hydrological, infrastructural, chemical or technical. As each phase of a project yields new data on aspects such as the soil structure or the level and quality of the groundwater, existing maps of the soil or the level and quality of the

groundwater, the contamination, the road plan and the built-up area often have to be either adapted or redrawn. Furthermore, the situation will change as a result of interventions. Such interventions will need to be integrated efficiently into the information system so that an up-to-date picture can be obtained when drawing up a remediation plan at the start of the remediation or at any given moment during the implementation.

To manage numerous locations which are all subject to a certain stage of supervision, remediation or permit

procedure and for which considerations and budgeting priorities are being weighed, an integral approach to information management is necessary. *(TNO Institute of Applied Geoscience)*

### Monitoring the ozone layer

The status of the ozone layer is a source of concern, and the need for reliable data on its composition is urgent. TNO has devised an instrument that will provide this data in the short term.

For some time efforts have focused on a sophisticated instrument designed to monitor the composition of the atmosphere from space. SCIAMACHY will, however, not be launched for several years to come. Time is of the essence. So when ESA (European Space Agency) announced in 1990 that room was available for an additional instrument on the ERS-2 (European Remote Sensing Satellite), an ozone monitor headed the list of options. TNO senior designer Huib Visser responded quickly. His design for a Global Ozone-Monitoring Experiment, abbreviated GOME, was received extremely well. GOME has a simpler structure than SCIAMACHY: GOME measures only directly downward, whereas SCIAMACHY observes the atmosphere at the Earth's horizon as well.

GOME was built in Italy whilst TNO was responsible for the calibration module which will ensure constant in-flight calibration, essential for obtaining reliable data. TNO has also been responsible for a facility unique in Europe which allows pre-flight calibration of the entire instrument.

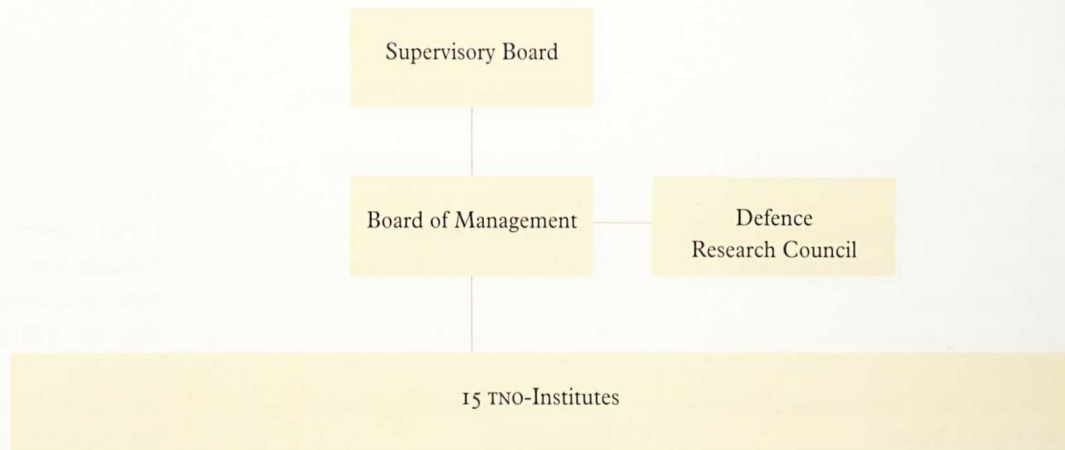
The ERS-2 was launched from French Guinea on 21 April 1995. At TNO, work continues on the analysis and validation of the in-orbit data received from GOME. *(TNO Institute of Applied Physics)*



*Launch of the ERS-2 satellite from French Guinea on 21 April 1995. On board is GOME, the instrument for ESA's Global Ozone-Monitoring Experiment. It was designed by TNO and built in Italy. TNO was also responsible for the calibration module which will ensure constant in-flight calibration, essential for obtaining reliable data on the condition of the ozone layer.*

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(situation as at 1 January 1995)



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