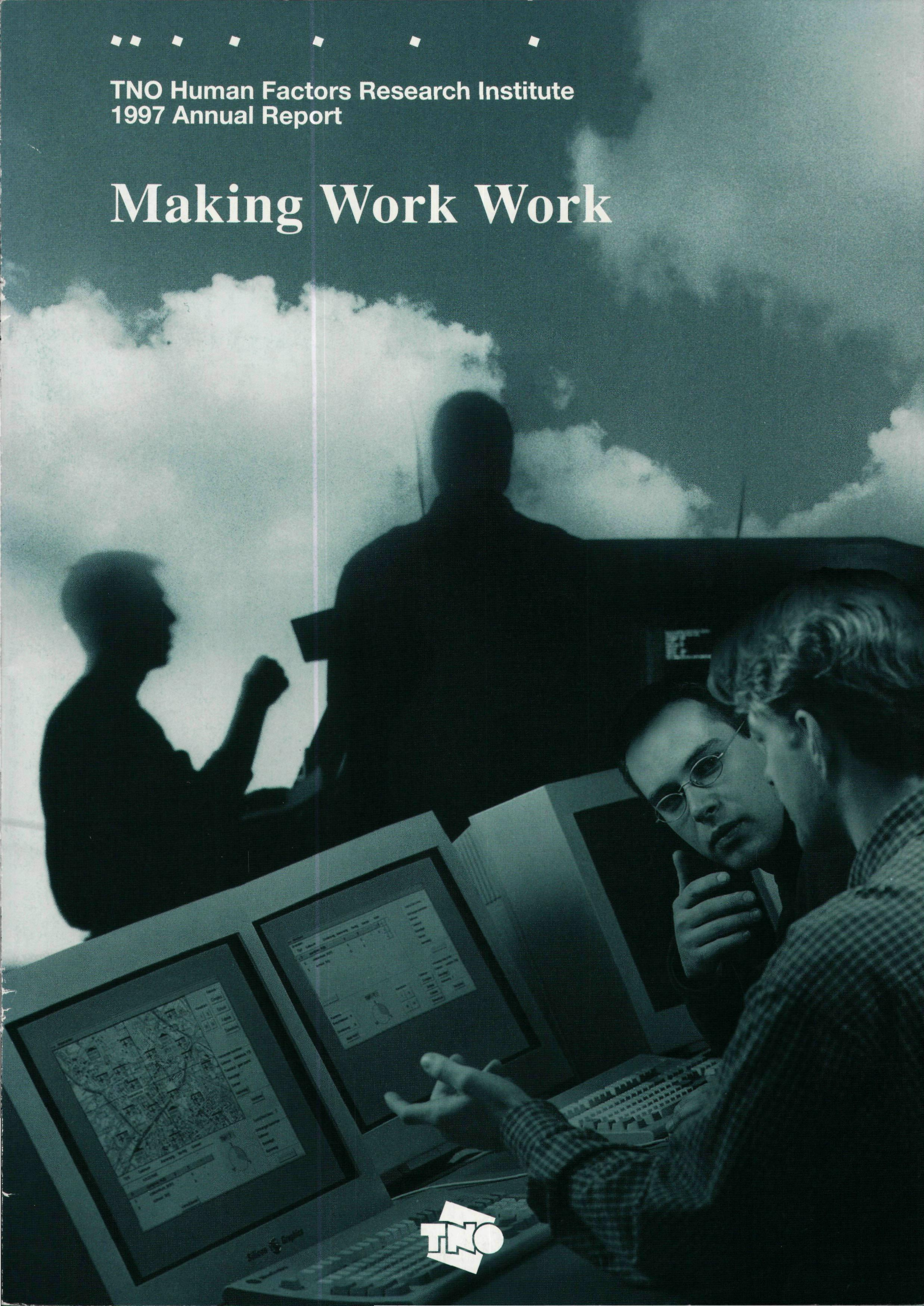
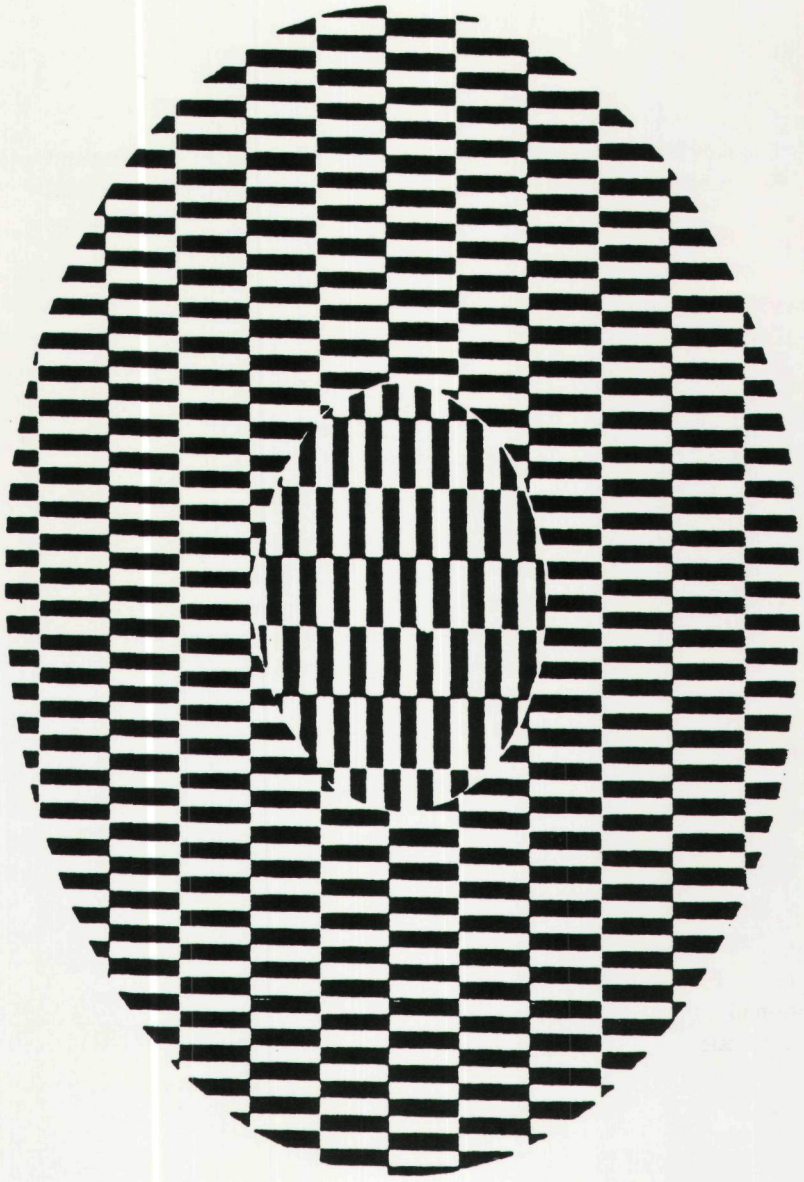
TNO Human Factors Research Institute
1997 Annual Report

Making Work Work





When moving this page up and down and to and fro, the centre of the representation moves independently of the background. TNO-HFRI too moves in its own way in a rapidly changing environment, which it is inextricably bound up with.

About learning and working together

Learning and working together typify the development of human factors expertise in 1997. The term human factors expertise stands for the knowledge of human functioning and its application in the design of technical (work) environments. Since learning and working together are important aspects in this context they necessitated the creation of a new research department of Training and Instruction as well as a new department of Group Work, next to the already existing departments of Perception, Information Processing, Skilled Behaviour and Work Environment.

Interest in learning processes is enormous. On the one hand, there is a permanent necessity: if you want to keep up to date you continually need to absorb knowledge and develop new skills. On the other hand, numerous technologies for training and instruction are emerging. One can speak of a particular technology push which urgently requires a re-evaluation of the question as to how learning processes actually develop and how they can best be supported.

Working together in groups receives much interest as well. This always concerns the organisation and the allocation of work on the one hand, and the psychosocial interactions within the group on the other. The Defense Organisation increasingly requires insight into team performance in the context of new operational settings and new technological possibilities for the distribution of the flow of information. Additionally, in the civil world of organisational consultant new insights into how people really perform in groups can undoubtedly be valuable additions to existing normative ideas.

For TNO-HFRI learning and working together are not just topics of study but they are also practice. Human factors is a typically multidisciplinary subject in which scientists with various backgrounds have learnt to work together, which has not always been easy. Instead of becoming undisciplinary, human factors should remain multidisciplinary and be the perfect synthesis of distinguished professional contributions. TNO-HFRI's cooperation with other research institutes within and outside TNO is based on this concept of complementarity of well-distinguished components. Important partners are TNO-Physics and Electronics Laboratory, TNO-Traffic and Transport, TNO-Multimedia and Telecommunications, Netherlands Institute for Working Conditions and Occupational Health Division of TNO, the Aero Medical Institute in Soesterberg and the recently-founded Telematics Institute in Enschede.

Finally, TNO-HFRI aims at continuously improving its collaboration with its clients at the Defense Organisation and others. Research projects can only be truly valuable when real answers are given to concrete questions and therefore we prefer to treat our clients as partners.

Dr.ir. A. Van Meeteren, Director

Knowledge matters

TNO-HFRI is a professional organisation and takes an internationally recognized prominent position in its field. Its adequate expertise meets the needs of its prime customer, the Defense Organisation. Besides, there is a substantial demand for a number of its research fields on the civil market.

At the beginning of 1997 the International Audit Committee confirmed TNO-HFRI's unique position in its final audit report carried out as part of a TNO-wide audit program. The Audit Committee especially supported the reevaluation of the portfolio of TNO-HFRI's disciplines, started earlier this year. At the end of the year, this resulted in 16 core fields of expertise, largely as an extension of the already existing portfolio. New are: decisionmaking processes, psychosocial interactions, team training and simulation. This restructuring of portfolio corresponds well with the shift of accents within the Defense Organisation and improves TNO-HFRI's growth potential on the civil market.

Perception
Vision and Imaging
Displays
Hearing
Speech

Work Environment
Workplace Ergonomics
Thermal Physiology
Equilibrium and Orientation

Information Processing
Cognition
Information Transfer
Simulation and Modelling

Training and Instruction
Learning Processes
Team Training

Skilled Behaviour
Steering and Control Making
Traffic Behaviour

Group Work
Distributed Decision
Psycho-social Interactions

As of January 1998 TNO-HFRI's research is divided into 6 Research Departments and 16 Program Groups.

We keep in touch

TNO-HFRI aims at further intensifying its account management both with the Defense Organisation and the civil sector. In 1997 this was done at a number of occasions.

In September TNO-Defense Research celebrated its 50th anniversary of Defense research within TNO with a symposium opened by His Royal Highness Prince Willem Alexander and an accompanying exhibition about product developments. At this occasion Defense Authorities stressed the importance of Defense Research again. Together with other research institutes we showed what we are capable of.

From the wing of bridge H.R.H. Prince Willem-Alexander casts a glance at the future Air Defence and Command Frigate ADCF.

TNO-HFRI's explorative research was the centre of attention at the 18th Military Symposium Day of 19 November organised by our institute. We successfully showed that our explorative research matches the demands of the Defense Organisation.
Special theme days such as those about Training simulators for unmanned vehicles and Sitting Comfort of driver seats were visited by many participants of the Armed Forces, industry and the government.

The staff of TNO-HFRI frequently held lectures and gave presentations and demonstrations at congresses, conferences, seminars, specialized fairs, exhibitions and other events at home and abroad. In this way we keep in touch with the outside world and with (potential) clients.

The national media brought our work to the attention of a wide audience and there was much interest in both our traffic research and the research about the confrontation method applied by the police regarding suspect identification by witnesses.

Dialogue in research

TNO-HFRI takes part in a wide network of collaborations within TNO, NATO, EUCLID, the European Union, Dutch Universities and with affiliated institutes. Also in 1997 many of our activities were carried out in collaboration with others.

The combined research of TNO-HFRI and its affiliated institute TNO-Physics and Electronics Laboratory regarding the flow of information and the decisionmaking processes on board of existing ships of the Royal Netherlands Navy deserves a special announcement. Further, the most important collaboration on the civil level is between TNO Traffic and Transport and TNO Multimedia and Telecommunications (TNO-MET). Within NATO the pattern of collaboration in the field of human factors was simplified by the creation of the Human Factors and Medical Panel under the Research and Technology Board. Finally, in December the long-existing informal collaboration between the National Air and Space Medical Centre NLRGC and TNO-HFRI was formalized. Meanwhile the name of the NLRGC was changed into Aeromedical Institute (AMI).

TNO-HFRI maintains close relations with relevant faculties of Dutch and foreign universities. Dr. A.H. Wertheim's appointment at he University of Utrecht as a professor of 'Applied Experimental Psychology, more specifically cognitive ergonomics' brings the total number of HFRI professors working part-time to five. Next to this we have an extensive program for PhD students.

In September Dr. H.A.M. Daanen completed his dissertation about 'Central and Peripheral Control of Finger Blood Flow in the Cold'. Two months later Dr. G. Havenith was next with his dissertation about 'Individual Heat Stress Response'.
Two guest researchers also completed their dissertations: Dr. B. Kappé about 'Visual Information in Virtual Environments' and Dr. E.L. Groen about 'Orientation to Gravity; Oculomotor and Perceptual Responses in Man'.
Professor Dr. A.W.K. Gaillard received the 1997 drs. J.J.F. van den Bergh award for his book 'Stress, Productivity and Health', which was published in 1996.

Working together

TNO-HFRI's research is multi-disciplinary. Psychologists, physicists, engineers, and biologists work together and are assisted by various services at our institute. All this in continuous dialogue with our customers.

At the end of 1997, 131 employees worked for TNO-HFRI and there were five vacancies. Compared to 1996 this means an increase by seven jobs. The growth which started in that year clearly continues.
As of 1 February Mrs P.M. van Bergem R.e. (Registered Ergonomist) has been appointed staff member of Communication and Head of the newly-created Communication and Information Office. This office is responsible for reprography, video, photography and graphics as well as for the library of our institute. Since mid 1997 Dr. J.E. de Graaf has worked as an account manager at Defense Research level for the Royal Netherlands Air Force.

For TNO-HFRI 1997 was once more a very good year. Staff members worked together harmoniously and did their jobs with great dedication. All this led to great results. With 176 reports, 50 memorandums and 77 scientific publications productivity remained well at level. We are in the fortunate position that there is a considerable demand for our work and apparently we seem to take advantage of this successfully.

Promotion Dr. Hein A.M. Daanen

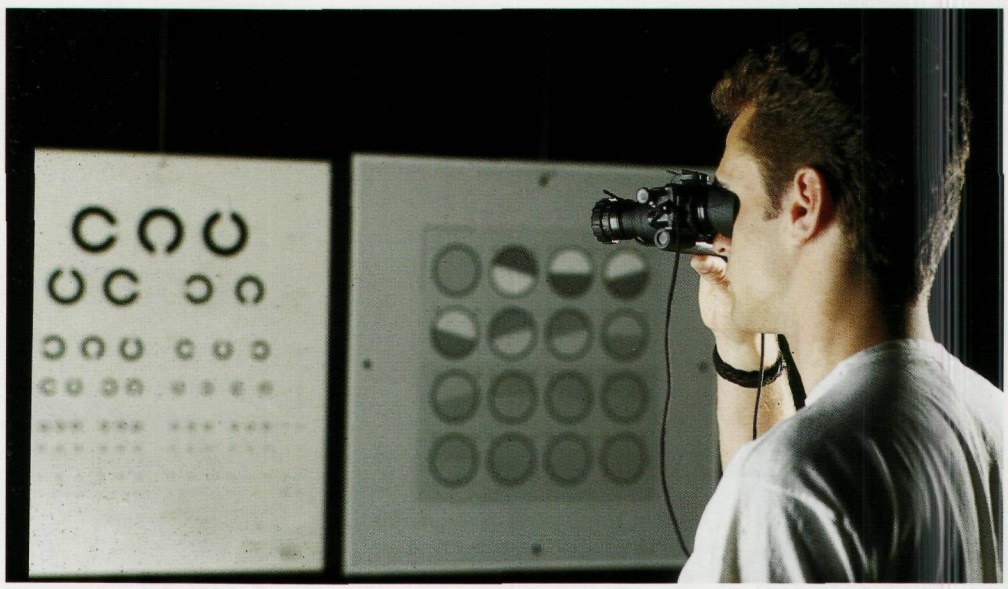
The Royal Army

The Royal Army is TNO-HFRI's biggest customer. In 1997 over 50 orders covering a wide range of topics were executed. This range reflects the tasks, equipment and training methods of the Royal Army with particular emphasis on electro-optical viewing, personal equipment, interface problems and the sensible use of simulators. Work was carried out for a cross-section of the various departments of the Royal Army, but most orders were received from the Directorate Equipment and the Training Command.

Electro-optical viewing remains a topical subject for the Royal Army. More compact thermal infra red imagers and image intensifiers are being developed and the latest models can also be carried. HFRI helped assessing the imagers offered. Checking the performance of the newly-introduced viewers used to be a laborious job. Yet, due to an improved method it has become much less complicated. The imagers no longer need to be taken apart and sent to a workshop and the results are more reliable than they used to be.
Attention was also paid to target search in the field. For this, practiced observers appear to use extremely different strategies. Despite all this the search time appears to correlate well with the target conspicuity, as measured with the conspicuity meter.

The validity of simulators requires our constant care. A non-valid simulator teaches the wrong things and therefore yields a non-optimal training transfer. Further, image delay creates an important problem during collective web-based training because information reaches one person sooner than the other. For this problem tolerances were specified. Moreover, it was investigated what performance measures for teams are suitable for measuring their progress.
An important aspect of vehicle simulators in particular is that they may not be too costly, otherwise a training in the real world is to be preferred. It was investigated how the complexity of the simulator can be reduced and how functionality can be improved. Advantages can be obtained with an image which is only detailed in the viewing direction.

Another issue of last year's research program was the improvement of the *functionality of vehicles*, which not only makes them safer and healthier to work in but also makes them last longer.
When driving on terrain it appears that armoured vehicles can be steered well when relying on camera images only. Using these fixed displays reduced the viewing problems encountered with conventional driving under armour. Head Mounted Devices would save space at the driver's work place but they do not yet provide an equally good view. However, in conjunction with the US Army they are being investigated further, especially their application in



The performance of image intensifiers offered is assessed by TNO-HFRI. Naturally this happens in the dark and, among others, by using various visual acuity charts.

On the Infantry Shooting Range ' De Harskamp' soldiers are trained in crawling across the ground under a 'layer' of machine-gun fire. TNO-HFRI investigated, among others, the safety of the shooting range during night-time use.

helicopters. Lack of space also appeared to be one of the problems of the new Fennek, which does not fit tall men. We did everything we possibly could to solve this problem, given the constraints regarding the signature of this vehicle.

Speech technology is an important issue in weapon systems. Computers can recognize and carry out commands spoken in noisy environments. Recognizing the speaker, however, is more difficult. It was investigated how systems will fail if voices change because of stress. A practical investigation aimed at using speech technology in Leopard II tanks. In such noisy environments the ears are sufficiently protected with conventional ear muffs against noise and damage caused by light arms but for heavy arms active noise reduction ('anti-noise') is required.

Information systems are becoming more and more complex, also those used by the Royal Army. Due to the increasing complexity users may have incorrect mental models of these systems. The purpose of the interface is to prevent this. This subject, which has been on HFRI's program for years, remains a topical subject. The interface for command and control systems is the Battlefield Management System (BMS). Assessments of the ergonomics and functionality of candidate BMS systems of the Fennek and the man-machine interface of the Integral Staff Information System were carried out.
Security systems also received much attention. HFRI advised about the protection of the Infantry Shooting Range and the safety at night with fire skimming over. Further, advice was given regarding the registration of shooting performances, the presentation of targets for the Stinger and Sperwer guided weapons and the radar surveillance trainer, etc.

The Soldier Modernization Program yielded, in close collaboration between the Defense Research laboratories, the first concrete results. Shooting with disconnected rifle sight, i.e. with camera view, not only offers better protection but also appears to have negative effects. The shooting accuracy is as good as with conventional shooting but it is a little slower and there is a higher risk of disorientation. This disorientation can be prevented with the Soldier Digital Assistant, which enables group consultations at a distance with the help of graphics. A first orientation was very promising.
In the mean time, the development and evaluation of other personal equipment continues. Much progress was also made with the automated 3D measuring of human bodies, this in view of the distribution of clothing.

More and more attention is being paid to *stress management and team performance*. Combined theoretical and experimental research yielded a framework for estimating stress tolerance and for improving it. One of the findings was that soldiers' behaviour under fire depends, among others, on stress tolerance. Unintended firing, however, appears to have a procedural background. The effects of working in groups were partly understood. It became clear that public feedback about personal performance is the best way of using social relations in order to keep team performance up to mark, also during very long-lasting missions.

With a disconnected rifle sight a soldier in combat can shoot from various positions without exposing himself, but using the weapon yields more than mere advantages.

Disconnected rifle sight

Within the Soldier Modernization Plan we are looking for, among other things, a more favourable relation between effectivity and risk. In the case of a soldier in combat this could be achieved by enabling him to shoot accurately without exposing himself. This is what the disconnected rifle sight aims at. The weapon contains a mounted camera which shows images on a display the soldier can watch without moving away from his shelter. The display can be attached to the weapon, but be visible from the side; it can be held in the hand or mounted before the eye. Shooting can be done very well in various unusual positions, but target search times are somewhat longer and the target cannot be seen equally well under all circumstances. Two cameras were therefore attached, one for searching and another for aiming. This worked already better, yet another phenomenon occurred, namely that the soldiers concentrated so much on the display that they forgot to check whether they were visible themselves. Consequently using a disconnected rifle sight requires at least some extra training.

Frank Kooi is a researcher with the Displays program group within the research Department of Perception. Together with other TNO Defence Research colleagues he is involved in the SMP.

"I expect that the miniaturisation of sensors and means of communication will change soldier's performance enormously. The question we are engaged in at HFRI is how this new technology can be applied without increasing the workload".

Royal Netherlands Air Force

The Royal Netherlands Air Force is a high-tech organisation with highly-qualified personnel and extreme working conditions and it is continually subjected to innovations. For TNO-HFRI this means working at a wide range of interesting subjects in the field of human factors research. In 1997 research was predominantly initiated by the Directorate of Materiel and the Operational Staff. The work can roughly be divided into three categories: Cockpit ergonomics, Training and simulation, Flight physiology.

Our expertise regarding *cockpit ergonomics* was used for improving several aspects of pilot's working conditions. Our specific knowledge about speech communication and active noise reduction was very convenient for solving communication problems at high noise levels in Chinook helicopters. The applicability of several types of pilot helmets, such as the helmet with Active Noise Reduction, were evaluated. Further, various disciplines worked together on developing measures to reduce the pilot workload. To this end, the operational applicabilities of spatial hearing (3D audio) for the localisation of target positions were investigated. Likewise, based on flight simulator experiments, helpful suggestions could be made for intuitively (and consequently fast) interpretable visual displays for the tactical information in cockpits of future generations of airplanes.

Within the framework of acquiring simulator facilities for *the training* of helicopter crews of the Chinook and Cougar transport helicopters we helped formulating simulator requirements. Next, new industrial products were assessed regarding their training value and technical feasibility. In conjunction with TNO-FEL it was investigated how Interactive Electronic Technical Manuals can be embedded in training and instruction aimed at maintenance and repair of systems used by the Royal Netherlands Air Force. This yielded, among others, an action plan for testing prototypes of didactic facilities on the basis of which better requirements can be formulated.
Due to the introduction of a new type of engine for the F-16, simulators and other educational tools used for the F-16 Specialist Engine training became obsolete. TNO-HFRI investigated what new educational tools were needed and in what training structure they can best be used.

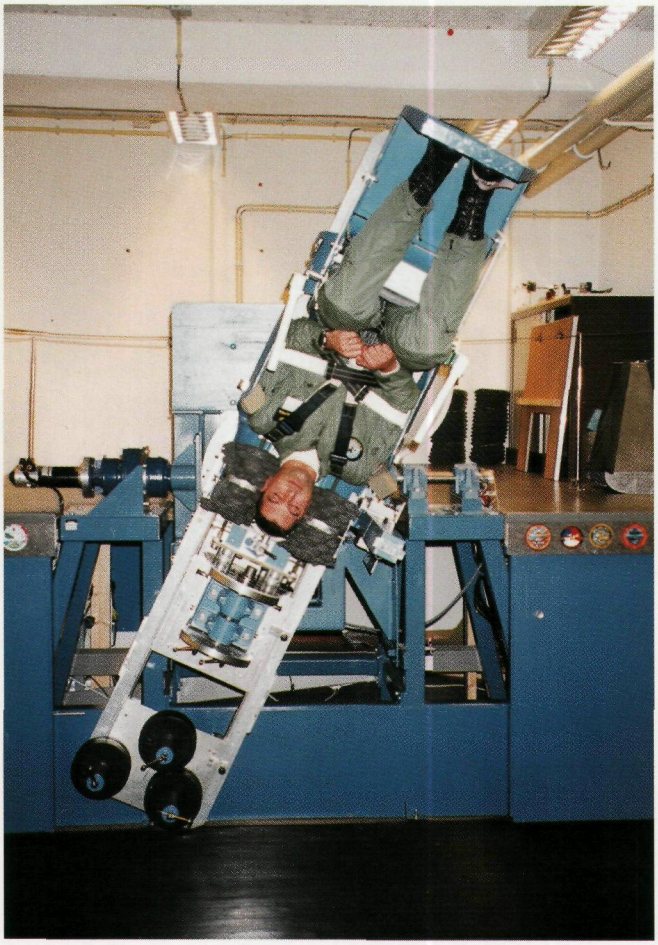
Flight physiology. Using digital manikins yielded new insights for extending as well as for refining the selection

In the Chinook helicopters the crews are exposed to high noise levels. TNO-HFRI investigated the possibilities of improving speech communication, among others by using various pilot helmets, including one with Active Noise Reduction.

criteria for pilots for the F-16 and Apache. The net result is that during testing less candidates will probably drop out for anthropometric reasons. TNO-HFRI also contributed to the Elementary Military Flight Training (EMVO) with a disorientation course. Pilot trainees were assisted in overcoming air sickness. The results of many years' research into pilots' spatial orientation were summarized in a model which includes the input of several senses. This model should now be useful for, among others, the specification of moving base simulators and the indication of human abilities as well as inabilities in the super agile plane.
For the analysis of pilots' physiological measurements in the air new software was developed with which data can be processed quickly and intelligently (allowing for artifacts).

The functions and tasks of the Multi-Purpose Armoured Vehicle were analysed based on a system ergonomics method. The program of demands as well as the various design concepts suggested by industry were investigated regarding physical-ergonomical aspects, making use of digital manikins. We also analysed the observer tasks that are relevant to the detection and identification of explosives and the aiming of firearms when working under armour.

Due to the introduction of a new type of engine for the F-16, investigations were carried out regarding changes in the F-16 Specialist Engine Training.



Disorientation demonstration
At the request of the Royal Netherlands Air Force TNO-HFRI has provided a disorientation demonstration course for pilots for several years. During this one-day course a variety of equipment is used to enable people to physically experience different forms of disorientation, with particular emphasis on the peculiarities and limits of the human senses. With these demonstrations the pilot is quickly made clear in what situations disorientation, and possibly also symptoms of motion sickness, can be expected and when not.
The disorientation demonstration course is still being developed and improved and is currently also receiving international attention. An Austrian company has commissioned the specification of a facility which supports the program designed.

During flying and in situations similar to those encountered by the pilot trainee on this picture, people get disoriented frequently. This is due to the fact that during transport situations there is a conflicting flow of sensorial information from which the observer should try to get a coherent view of the world. In this, however, he does not always succeed. The pilot trainee on this picture explains that, after about 10 seconds of rotation, he no longer feels that he is turning over. This illustrates the peculiarity of the human vestibular system that responds to accelerations and not to constant speed.

Jan van de Kooij is the 'skipper' of TNO's 3-D swivel chair. Although he feels exhausted after a one-day disorientation demonstration course he is happy and content in the evening. The pilots' surprise at the limitations of the senses in a flight situation as well as the odd and sensational delusions they experience on Jan's swivel chair make up for such a strenuous day of dragging, adjusting and reconfiguring the chair.
"It's great to be able to be of direct use for our client now. Besides, these pilots are nice guys and girls. In this way I hope to contribute to their flight safety".

Seeing is believing

A critical success-factor for videoconferencing applications is tuning its functionalities to the requirements for effective human visual communication. Previously, we showed that directional gaze (an innovative feature of multi-point videoconferencing) strongly improves persuasive force compared with current video systems. This year we focussed on how video-features such as size, color and update-frequency affect people's ratings of video quality, tele-presence, confidence, etc. By order of Holland Signaal we studied videoconferencing applications in the navy.

Royal Netherlands Navy

The Royal Netherlands Navy has always seen the value of the human factor in its technologically advanced environments. That is why TNO-HFRI and the Navy continue their collaboration on a great number of fields of research. In 1997 this research mainly concerned the information transfer in operational workspaces of frigates and minewarfare vessels. Moreover, attention was paid to improving training and to analysing the mental workload of the Lynx helicopter crew.

For the future air defence and command frigate (ADCF) which is replacing the guided missile frigate as of 2001 advice was given about *the design of operational workspaces*. The lay out of the bridge, the operations room, staff room, the radio centre and the ship control centre were designed on the basis of scenario, function and task analysis. The design of the interfaces is also based on these analyses. Mock-ups were built for, among others, the bridge and the operations room of the ADCF and over 70 Navy officials judged the design. Further, the bridge lay out was adjusted in order to install the Electronic Chart Display and Information System (ECDIS). The outside view from the bridge was evaluated with the help of virtual environment techniques, which created a nearly perfect surround view.

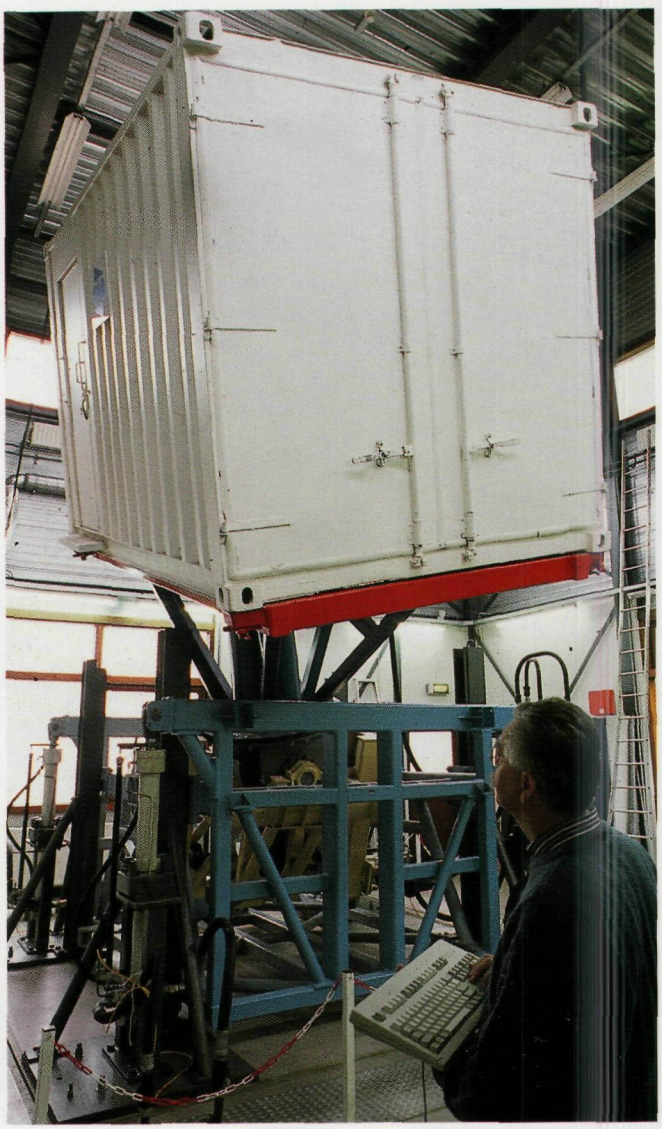
Other studies for the ADCF were specifically aimed at the *transfer of information in the operations room*. To support the consultation between members of the command team we evaluated the possibilities of using Large Screen Displays of air and surface picture. Thus recommendations about the application of this type of displays could be made.

Navy officials evaluate the design of the operations room of the ADCF in the mock-up.

Also the application of 3D audio displays was investigated. With this way of presentation it appeared that speech intelligibility in multi-channel communication could be improved. Another application of 3D sound presentation is the support of spatial orientation by auditorally indicating the positions of targets, threats, etc. Navigating unmanned aerial vehicles from the operations room for remote observation is not easy and can lead to disorientation and bad performance. The remote control interface was optimised for the parameters image update frequency, time delay and predictive display.
In conjunction with TNO-FEL the study 'flow of information at the multi-functional Frigate' was started. The purpose of the study is to identify bottlenecks that can cause the workload of the staff at the operations room to be either too heavy or too light.

Various innovations in the field of *instruction and training* were guided extensively with the methodology of Structured Trouble Shooting. Another methodology was developed for a careful consideration of the use of training tools. Notably the purchase of training tools for the technical training for the ADCF and the project 'adaptation minewarfare vessel' (PAM) was supported. This mainly concerned the design of Computer Based Training, simulators and the type one-on-one trainers.

The size of the crew on ships gradually decreases. Consequently missions tend to become more dependent on the performance of few people. Anticipating this fact research was done about the influence of ship movements on *motion sickness and task performance*. Based on knowledge about the vestibular system (without which people do not get seasick) a model was made for predicting seasickness (and consequently also task performance) as a function of the most important motion factor (heaving). TNO's ship motion simulator already showed that roll and pitch significantly contribute to this. It has also been investigated how all this can be included in a predictive model and this will eventually yield a more applicable motion sickness model.



TNO's ship motion simulator is a cabin of more than two by two by four meters, placed on a post of about two meters. The entire simulator can move up and down (heaving) and can rotate around a point located below that post, both sideways (rolling) and to and fro (pitching). In the cabin several people can be exposed to (ship) motions while they can perform a task. For these tasks one can think of reading, manual and physical work but also of eating, drinking and relaxation. This enables a controlled investigation of the influence of motions on task performance, even on days when the sea is as smooth as glass.

During the investigation the Lynx helicopter crew carried out an anti submarine warfare mission

The workload of the LYNX helicopter crew

In some years the LYNX helicopter will be replaced by the NH-90 helicopter. This helicopter will be equipped with more sensors and a new cockpit, as a result of which many tasks will have to be carried out differently. The question is what the consequences will be for the workload of the tactical coordinator (TACCO), the pilot and the sensor operator.

As part of the investigation crews executed an anti submarine warfare mission in the Lynx simulator. Afterwards the workload was analysed with the help of video images. On the basis of these images, the crew indicated when tasks were performed and how much effort was put in the execution of the tasks. From the workload analysis it appeared that the TACCO's heaviest workload occurred during "contact" and "attack", the pilot's during "return" and the sensor operator's during "search", "contact" and "attack". Especially the forming of an accurate mental representation of the surroundings and of the situation of the helicopter (situational awareness) are particularly strenuous for the TACCO and the pilot. When equipping the NH-90 cockpit, special attention will be paid to tools for accurate situation awareness.

Hans Veltman is a researcher with the group Steering and Control within the Research Department of Skilled Behaviour.

"The crew was very motivated and involved with the research. Next to the large amount of useful measuring results my knowledge about working in complex task environments has increased considerably".

Central Organisation

TNO-HFRI's research carried out for the Central Organisation usually covers a wide range of topics for the Defense Organisation. We mainly focussed on three categories: medically-oriented research, which essentially concerns testing and protection; environmental research, especially aimed at noise annoyance; and the European-coordinated research in the field of training and simulators.

Interesting developments are occurring in the field of *hearing protection*, in particular impulse noise. To mention a few: testing individual sensitivity, new insights into physiological processes preventing noise-induced hearing damage and new hearing protection devices. Internationally, insights and criteria important for minimising the risk of permanent hearing damage were coordinated within NATO RSG.29/panel 8.
Motion sickness is another important component of the testing and guiding of operational personnel at the Royal Netherlands Air Force and Navy. HFRI's facilities for various types of motion stimulation were used for the investigation of the adaptation of the vestibular system of Air Force pilots. The question whether individual differences can be predicted on the basis of an extensive array of tests was of particular interest.

A head-slaved high resolution window and basic peripheral information appear to yield advantages for low-cost simulators.

In order to be able to comply with (future) environmental laws, among others the Environmental Effect Reports (MER), many investigations were carried out concerning *aspects of noise annoyance* of military shooting ranges. The question regarding the annoyance-relevant physical measures of light and heavy arms impulse noise received special attention. Based on previous laboratory experiments with many subjects a simple rule could be derived for correctly describing the effects of spectral features of various impulse noises. With a literature study about annoyance caused by artillery shooting ranges this rule could be validated.

Training and Instruction are of the utmost importance to the entire Military Forces. The start of the EUCLID project RTP 11.8 instigated the development of 'Low-cost' simulators for all military training. Based on a detailed analysis nine fields of training were identified, showing an interesting potential for applications of low-cost simulators.
Finally, four of these fields were selected for further research, namely driving proficiency training, Unmanned Aerial Vehicle (UAV) operator training, training for using electro-optical equipment and mission management training. For generic low-cost training simulators for these fields functional specifications were given.
Besides, we participated in EUCLID RTP 11.1, the MASTER project (Military Application of Simulation and Training Concepts based on Empirical Research). This project aims at issues important for designing effective training programs. We investigated experimentally to what extent the persistence of task competence trained was affected by the kind of instruction received during the learning process. The results showed that insight into the underlying principles of a system are essential for maintaining skills after a period without practice. The European programs mentioned above will be continued in 1998.

While carrying out a thorax drainage a medical NCO is being advised by a specialist at another location. The specialist watches the operation through a camera mounted on the soldier's shoulder. The soldier communicates with the specialist through the headset.

Telemedicine - Direct teleconsultation and Telesurgery

The purpose of the telemedicine project is to realise possibilities of transferring the right knowledge and experience to the place of an incident with the help of teleconsultation. In areas that are difficult to reach direct teleconsultation is an appropriate solution for bridging the lack of expertise and experience at the place of the disaster. For the Air Force this could be, for example, assisting the medic or advising a surgeon at the field hospital. Regarding this matter human factors research tries to find a suitable system configuration that can provide the transfer of the information required. The procedure used by a medic or surgeon working together with a tele-specialist makes demands on particular conditions regarding the system as well as the conversation. An additional complication is the delay in remote camera control by a specialist.

Andrea Hin, researcher with the Workplace Ergonomics program group of the Department of Work Environment, about the Telemedicine project:
"Especially the possibility of experimenting in realistic situations at the Royal Army yields so much valuable information. How practical are the various configurations of close-up and overview cameras and how are they being used? From behind your desk you cannot possibly answer these questions".

Civil research

Of old, TNO-HFRI's expertise and research facilities are also used for the civil market. Research activities for this market in their turn provide applicable knowledge for the Defense Organisation. Research for both markets is therefore mutually supportive and this so-called 'dual-use' policy has been intensified in the last few years.

The 1997 turnover of our civil research increased more than had been planned. The realised turnover of 7.2 million guilders represented approximately 33% of TNO-HFRI's entire turnover for that year. Again, these good results confirmed HFRI's potential to grow, firstly because the amount of work increased in 1997 and secondly as a result of several large-scale initiatives stimulated by the government and trade and industry together. Some of these initiatives are: the Innovative Research Program for Man Machine Interaction and the important role 'human factors' was assigned within the program of the new Telematics Institute. In the light of these developments TNO-HFRI can readily associate with the growth policy stipulated in TNO's new note on strategy. However, it is required that this development is in accordance with the interests of Defense research and the policy of the Council of Defense Research.

For the Ministry of Transport Public Works and Water Management, which was again our biggest civil customer, we worked, among other things, at dynamic public lighting, special dedicated lanes, dynamic route information panels and automatic vehicle guidance. Some of last year's customers from trade and industry were Schiphol Airport, KLM, Signaal, NS, DHV, Heidemij Advies, KPN, Siemens, 3M and Schindler elevators. Some of our foreign customers were Caterpillar, the US Department of Transportation and Braun AG.

From the range of numerous topics TNO-HFRI dealt with for the civil market in 1997 a brief summary can be given:
For the Radio Communication Agency we investigated the mutual influence of FM-channels with nearby frequencies. Based on the results recommendations could be given for the optimal distribution of available channel frequencies while retaining sound-quality.

With the conspicuity method developed by TNO-HFRI a comparison was made of the visibility of approaching trains, as seen by railway workers.

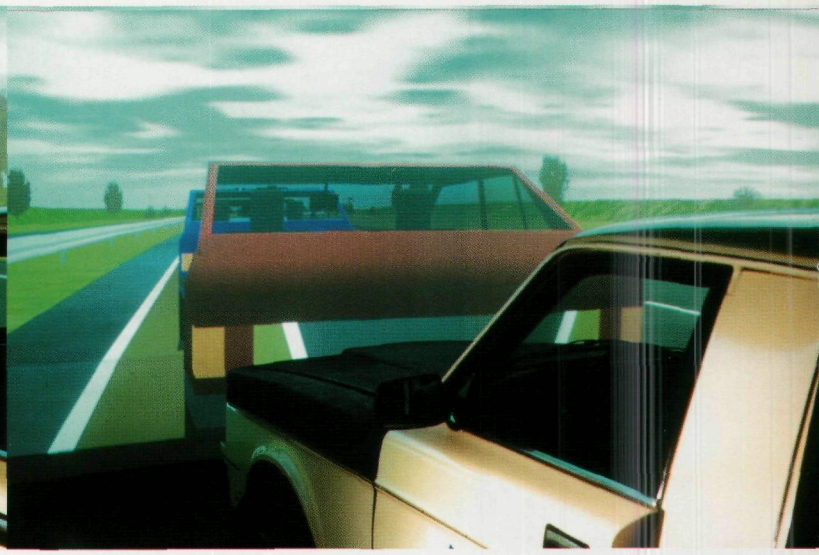
For the Volkerak sluice complex the application of a number of operating concepts were analysed. Especially the combined operation of bridges and sluice gates could be optimized. A new, compact work place was designed and guidelines were drawn up for the control devices of sluice complexes.
The Royal Society of Dutch Ship Owners asked us to carry out a comparative research about one-man versus two-man bridge occupation in the dark. The results show that on integrated bridges with an officer of the wait as the only lookout at least the same level of safety can be achieved than on conventional bridges staffed by two.
Emerging drowsiness of car drivers appears to be predicted well with the help of the Time-to-Line-Crossing Measure. This can be measured readily and reliably on-line during driving. Really dangerous behaviour reveals itself a few minutes in advance.
TNO-HFRI surprised with its finding that meeting through video-conferencing proceeds much better in some respects when compared to face-to-face meetings. This is especially true for arrangements enabling selective gaze.
At the request of ESA a usability engineering method was devised in a Danish-Dutch consortium. This method became available in an electronic version for the design of man-machine interfaces for payload operations in space missions.

Other subjects that were dealt with for civil customers were:

- Frontal view conspicuity of trains; NS Railned.
- Acceptance of energy-saving lighting; Novem, Energie-Ned, Kema.
- Use of colour on displays for supervisory control; Dupont de Nemours.
- Quality of speech communication systems; Directorate General of Public Works and Water Management, KLM.
- Workload of operators dealing with 1-1-2 calls; KLPD.
- Automisation of control of earthmoving machines; Caterpillar.
- Training of Structured Trouble Shooting; Vaillant, Schindler, Directorate General of Public Works and Water Management.
- Design of video conferencing / group decision room; Ministry of Housing, Planning and Environmental Management.
- Moving comfort of movements on board of luxurious motor-yachts; Feadship.

Experimental set-up for the investigation of advantages and disadvantages of video conferencing. In some respects video conferencing is improved by selective gaze.

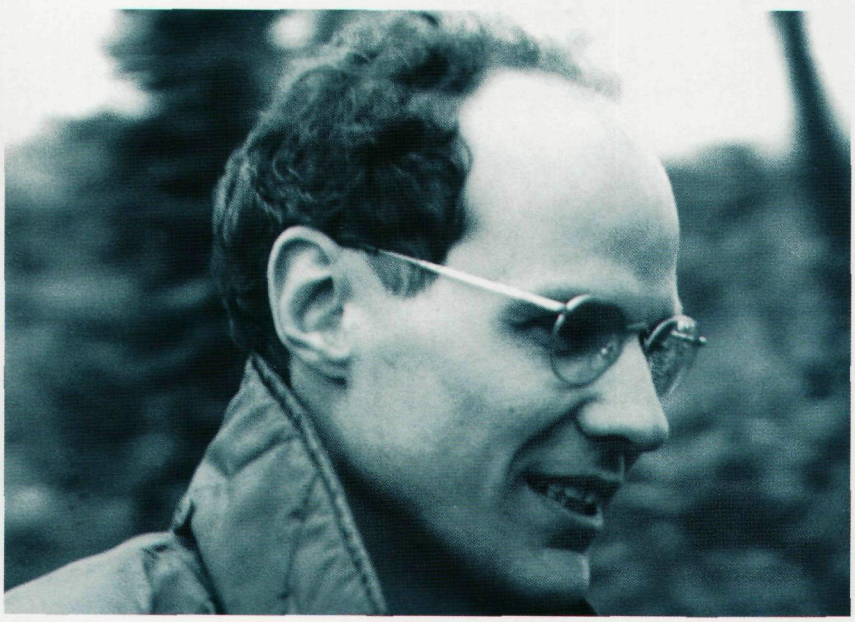
AVG driving with a three-second headway.



AVG driving with a 0.01-second headway.

Automatic Vehicle Guidance

Automatic Vehicle Guidance (AVG) - with which systems are meant that support the driver's driving task and take over control partly or completely - is regarded as a promising device for eventually improving the quality of road-traffic (safety and traffic flow) in the future. Its feasibility will greatly depend on how users can and want to deal with AVG systems. For obtaining a better understanding of this matter TNO-HFRI investigated several human factors aspects of AVG in the driving simulator, such as the acceptance of extremely short headways, driving in narrow lanes and transitions to road-sections without AVG. The simulator studies showed a monotonic decrease of driver comfort when headway decreased, also for systems that prevent collisions at all times. Setting up barriers as physical separations between lanes for conventional traffic produces no effect on driving comfort during automised driving, but they have a clear effect when driving manually on the AVG lane. When returning control at transitions to road-sections without AVG, drivers prefer taking over the steering immediately rather than gradually taking-over supported by the computer when pulling out.



Alexander de Vos is a researcher with the Traffic Behaviour program group within the Research Department of Skilled Behaviour.

"I have high expectations of the large-scale AVG demonstration organised by the Directorate General of Public Works and Water Management in conjunction with TNO and the European Committee and which will be held on the N11 near Renswoude in June 1998. With our instrumented car ICACAD we will show how an 'Adaptive Cruise Control' system influences the visual workload of the driver".

Oslo confrontation

Visual identification of suspects in person, on video or on photos?

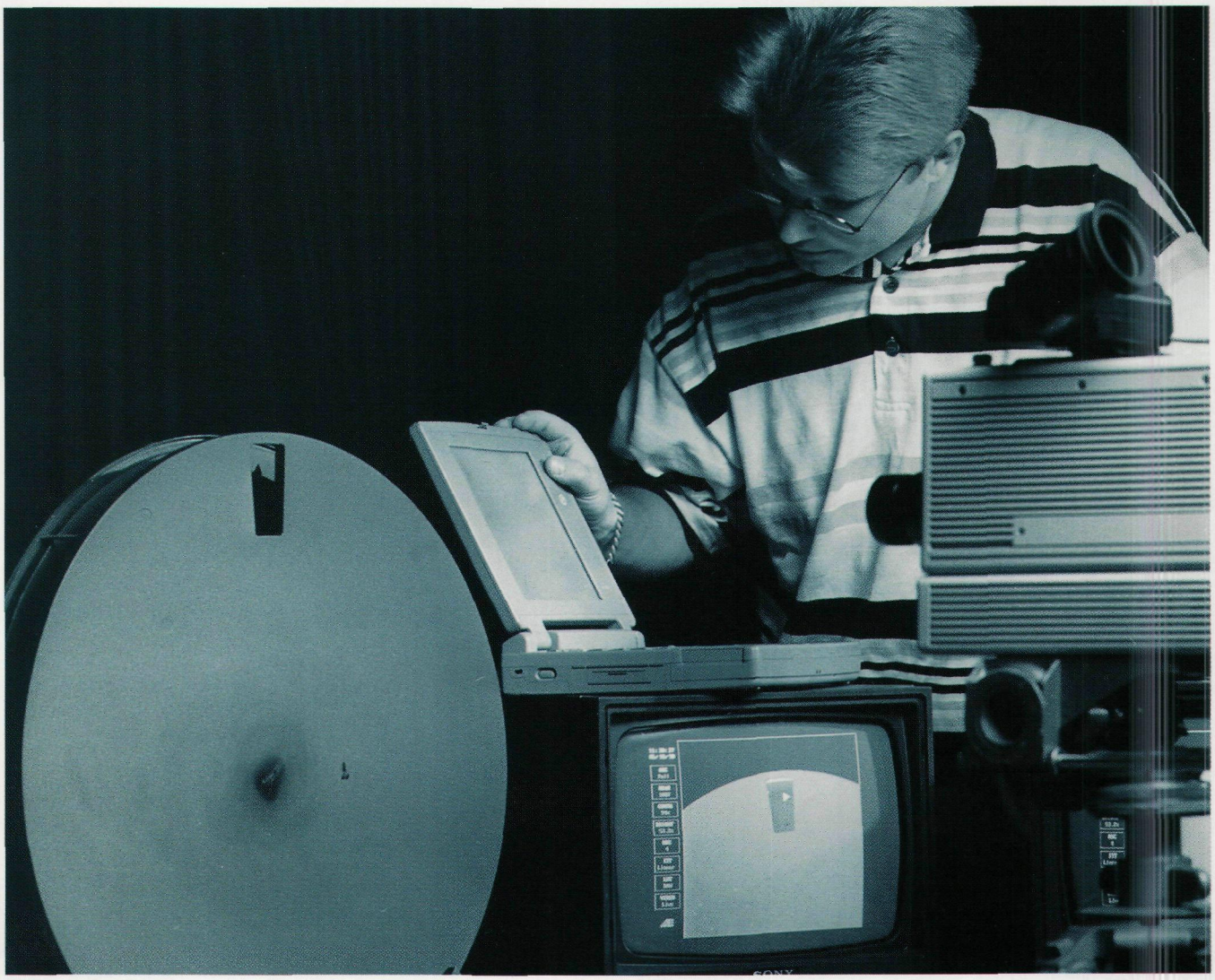
Eyewitnesses' statements form an important part of the argumentation in many lawsuits. Is the suspect really the same person the witness saw at the place of the crime? For the Ministry of Justice the effectivity of three confrontation methods was compared, namely static confrontation in person (Oslo confrontation), video and photo confrontation. Subjects who were under the impression that they had to do a memory task, witnessed - before starting with this task - a staged incident. After doing the memory task they had to identify the person involved in the incident, using one of the three confrontation methods. The results showed that the 'offender' was identified correctly just as often with all three methods. However, with both video and photo confrontations in selections in which the 'offender' had been left out, someone was pointed out wrongly more often than with the Oslo confrontation. Of course, in forensic research chances of wrong identification weigh heavily and therefore the Oslo confrontation is to be preferred. The costs of this method, however, are high and its practical feasibility is relatively low. Regarding both aspects video confrontation offers various distinct advantages. Further research will have to show to what extent this method can be improved, perhaps by showing more 'cues' such as posture, locomotion and gestures.

José Kerstholt, program leader of the group Cognition within the research Department of Information Processing, about the project 'Methods of Identification':

"For these experiments it was very important that the subjects could not communicate with each other. Therefore, the experiments were done in Soesterberg, Zutphen and Amsterdam".

Explorative research

It is necessary to anticipate the questions of the future. TNO-HFRI's explorative research aims at renewing and maintaining our expertise in such a way that - in the near and distant future - we can readily and efficiently anticipate the questions arising at the time. The development and growth of new information and communication technologies have major, and still partly unanticipated, consequences for the functioning of society, particularly for the armed forces, traffic and transport systems and the educational structure. This will yield new questions regarding userfriendliness and behavioural effects.



TNO-HFRI has developed a new method for testing thermal imagers. This method has been implemented in the 'TIPI' (Thermal Image Performance Indicator). The system consists of a thermic stimulus generator with which different thermic test patterns can be generated and a laptop PC which controls and checks the measurement.

At the Department of *Perception* knowledge about observer performance with modern thermal imagers and image intensifiers was used for developing a simple measuring method. The validity of this method (TOD, Triangle Orientation Discrimination) was shown by an extensive study about ship recognition. How the subjective image quality can be improved, for example by image fusion and colour transformation, will be investigated in two IOP programs in the next few years. Within these programs we work together with the Universities of Delft and Utrecht as well as with trade and industry. In a first series of experiments on the fusion of image and sound it was determined which correspondence in motion and position of image and sound is required for perceptional fusion.
Speech research showed that the automatic speaker recogniser practically equals recognition by humans. This indicates that this technology is growing out of its infancy and has an enormous potential of applications.

The Department of *Information Processing* was especially dealing with the question of how users of modern information systems can be assisted in finding their way in complex databases. It was determined what features of the interface structure and menu presentation influence this navigation task. Perspective displays appear to improve the supervisory control task, but at the same time the ease of direct process control can decrease because of this.
Effective team performance proves to depend strongly on the way in which team members exchange information. It was found that members of well-performing teams not only keep each other informed about the results of their activities, but also give additional information, such as information about what they are doing. This has important implications for the development of operations rooms, because so far this kind of need of information has never been taken into account when designing these centres.

Group functioning also depends on the way in which a team is being trained. This aspect was investigated by the Department of *Skilled Behaviour*. It became obvious that it is not very efficient for all team members to fully train in each other's tasks. A better result can be achieved if the various team members are well-informed about each other's information need.
Further, this Department investigated how a control task should be distributed among machine and operator in future use of unmanned systems. The steering performance of the operator, who is located at a ground station or on board of the mother ship or plane, appears to be quite dependent on the qualities of the steering interface. The automisation of control tasks will not only play an important part in Defense tasks but also in the field of road traffic. In conjunction with TNO-partners the traffic simulation model MIXIC was developed in the last few years. The model, including the behaviourial effects implemented in it, was connected to the driving simulator. Automisation may lead to negligence of the operator or car driver. Within the framework of the EU-project SAVE, measures were developed with which the occurrence of errors and accidents caused by drowsiness can be predicted timely.

For determining the workload of pilots the Department of *Work Environment* developed a combination of physiological and subjective methods. Both heat stress research and cold tolerance research were concluded with a dissertation. The expertise gained in both research projects has already been used for a considerable time, for example in computer models.
When developing equipment for the soldier of the future - within the framework of the TNO-wide Soldier Modernization Program - problems with full head protection are expected. In order to improve wearing comfort and protection against gas it is possible to apply some over pressure under the mask.
Vestibular research has now progressed to an extent that a predictive mathematical model is available with which, for vertical movements, the probability of getting motion sick can be predicted. This model will still be extended with the effect of rotations, horizontal translations and viewing aspects. This will enable the prediction of simulator sickness.
Teleworkplace research yielded surprising first insights into the optimal use of video-conferencing. Selective gaze appears to have considerable effects on persuasive force. Video-conferencing also creates a better team spirit compared to working face-to-face.

A team of subjects is working on the TANDEM task, consisting of a distributed simulation with which the distribution of tasks, mutual dependence and working conditions, including time pressure, are simulated.

Teamtraining: from a group of experts towards an expert team

In many complex tasks, such as Command and Control (C2), people work in teams to finish tasks and missions successfully. During the practical training of teams, however, team aspects are usually not considered explicitly. Mostly team members have to find out themselves in what way team activities can best be organised. Many people think that cross training, a training strategy in which every team member is being trained in the tasks, responsibilities and the information needs of other team members, is a suitable method for improving team performance.

How can cross training best be designed? Does practicing the tasks of others really lead to improved team performance? If so, is it necessary for team members to fully train in each other's tasks? This does not seem to be required for improving the communication and coordination within a team. In many cases this will even be impractical and far too costly.

Research aimed at the above-mentioned questions was carried out with the help of the Tactical Naval Decision Making Task (TANDEM). This task is typical of teams in C2 surroundings. During the execution of the TANDEM task three subjects work together as a team to correctly identify unidentified contacts on a radar screen and subsequently counteract adequately.

The research shows that the way in which cross training is designed can lead to important differences in the functioning and performance of teams. The most important result is that for optimal team performance it is not necessary to provide team members with a complete insight into the tasks of fellow team members. It is better to inform team members explicitly of the existing relations and dependencies between the personal task and that of others.

Alma Schaafstal, program leader Team Training within the research Department of Training & Instruction: *"Although research was carried out in a C2 environment, the results can be generalised to other environments as well. Everywhere where people from different subgroups have to work together to finish a job it is important to inform them sufficiently about the tasks of the other team members so that they can adequately anticipate each other's information need. In this way team training can be an important factor in the optimisation of team functioning and team performance".*

Financial report for the year 1997
TNO-HFRI

In 1997 TNO-HFRI had a turnover of 22.2 million guilders. Sixty seven per cent of the turnover (14.8 million guilders) involved projects for the Defense Organisation - explorative research and dealing with concrete projects. Thirty three per cent came from civil research (7.2 million guilders).

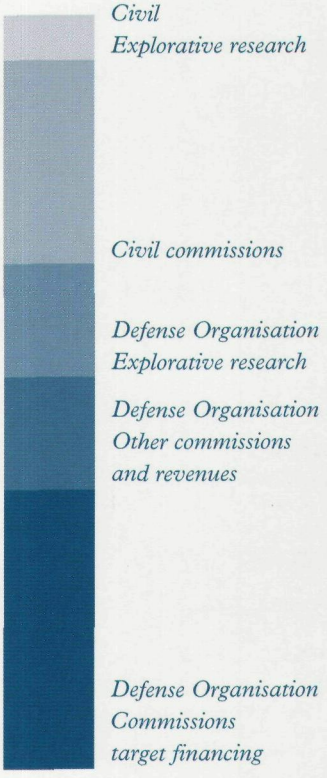
Against the 22.2 million guilder revenues were the expenses of 21.3 million guilders, so that 1997 ended with a positive result of almost 1 million guilders.

In 1997 the investments amounted to 1.3 million guilders. Next to the usual package of expenses of minor and more substantial sums of money, TNO-HFRI invested in the purchase of a 3D anthropometric scanner, the replacement of administrative systems, the purchase of a see-through Helmet Mounted Display, software for VE programming, and an expansion of simulation facilities for Command & Control.

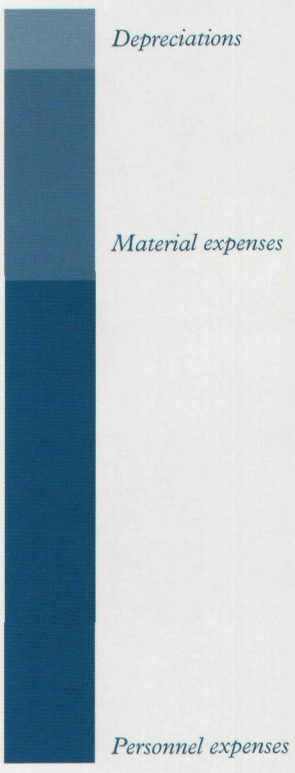
Revenues	**'95**	**'96**	**'97**
Defense Organisation			
Commissions target financing	8.350	8.137	8.214
Other Commissions	1.897	2.792	3.248
Explorative Research	3.355	3.404	3.376
Total Defense	**13.602**	**14.333**	**14.838**
Civil			
Commissions	4.070	5.405	5.826
Explorative Research	1.105	1.398	1.390
Total Civil	**5.175**	**6.803**	**7.216**
Other revenues	**122**	**162**	**198**
Total revenue	***18.899***	***21.298***	***22.252***
Expenditures			
Personnel expenses	12.285	13.172	13.585
Material expenses	4.425	5.999	5.994
Depreciations	1.130	1.122	1.702
Total expenditure	***17.840***	***20.293***	***21.282***
Results	**1.059**	**1.005**	**971**

(sums x NLG 1,000.00)

Division of revenues 1997



Division of expenses 1997



TNO-HFRI

(as of 1 January 1998)

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