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Summary

An overview is presented of the scientific infrastructure for activities in Medical Technology in Europe, the Netherlands and in more detail for the province Noord-Brabant. Facts and figures of the relevant programs of the EC for this domain are dealt with in paragraph 1. Paragraph 2 highlights the educational standards of the Netherlands as well as the achievements of academic researchers in Dutch universities and research institutes. The third paragraph provides a summary of the R&D programs of the Eindhoven University of Technology. The paper ends with a reflection on programs considered of importance for the Netherlands in the near future.

R&D programs in the EC.

The annual budget of the European technological R&D programs in 1994 exceeds 2 billion US$. The programmes within the European Union are set-up in four year periods. Currently the IIIrd Framework Programme (1991-1994) is active. The main fields of the technological R&D are listed in figure 1.

* TELEMATICS (530 Million US$) including AIM (Advanced Informatics in Medicine), TIDE (Technological Innovations for Disabled and Elderly), DRIVE (Dedicated Road Infrastructure for Vehicle safety in Europe), LRE (Linguistics Research and Engineering) - development of information and communication technologies that are applicable in sectors considered of importance to society as a whole.
* **BIOMED** (185 Million US$, including the Human Genome Analysis Program)
  - health problems (cancer, AIDS, age related health problems, environmental and life-style related problems)
  - health provisions (development of medical technology, health services research).
  - medical ethics
  - Human Genome Analysis (20 Million US$)
  - improvement of human genome maps
  - realization of organized depots of human DNA-clones
  - improvement of advanced gen-technology
  - training.
* **ESPRIT**: European Strategic Program for Research and development in Information Technologies (2 Billion US$) (partly MT)
  - development of basic technologies for the European industry.
* **RACE**: Research and development in Advanced Communication technologies for Europe (700 Million US$) (partly MT)
  - development of functional specifications for various user groups (Integrated Broadband Communication with ISDN).
* **BIOTECH**: Biotechnology Research program for Innovation and Developmental Growth in Europe. (200 Million US$)
  - faster production of biological data, materials and procedures, aimed at optimal use of biological and natural resources.
  - scientific networking in the disciplines of technology, physics and life sciences.

**Fig. 2 EC-PROGRAMMES**
It is foreseen that the IVth Framework programme will have a total budget of 15 billion US$, which means an increase of the budget of 100% for technological and technology related R&D.

The EFTA-countries (European Free Trade Area) in Europe collaborate in two MT-relevant programs i.e. COST and EUREKA. Under COST (COoperation europeenne dans le domaine de la recherche Scientifique et Technique) a great variety of topics is elaborated among which a lot deal with medical technology. EUREKA is market oriented in comparison to the more precompetitive and fundamental EC-programs. The present running budget of EUREKA-projects exceeds 13 Billion US$.

In general, the following organizations can participate in the EC programs:
- companies, especially Small and Medium Enterprises (SME)
- universities
- research institutes.

A SME, by definition, is a company with less than 500 employees, a net turnover of less than 53 Million US$, is located in the EC, and is limited to no more than 1/3 ownership by a holding company or other organization. When companies participate in EC programs their contribution to projects may vary between as little as 20% up to 50% of the total budget of the project. This percentage depends on the precompetitive character of the R&D in the project.

**R&D in the Netherlands**

The annual governmental support for universities and schools for high vocational training is approximately 4 Billion US$, which is about 2% of the Dutch GNP. This sum includes the budgets for university hospitals and non-university research institutes.

*Fig. 3 Annual governmental support for universities and schools for high vocational training*
About 402,000 students follow an undergraduate training, that is 2.7% of the total population. The Netherlands has the highest number of students per million inhabitants in Europe.

**Fig. 4 Students/million inhabitants (x 1000)**

Over 20% of Dutch employees have finished an undergraduate training. It is expected that this will increase to 25% in the year 2000. The total scientific staff in universities equals over 67,000 f.t.e (full time equivalent) per annum. Relatively, the Dutch expenditures on R&D are as high as in France and the United Kingdom, higher than in Belgium and Denmark, but lower than in Sweden and Germany.

**Fig. 5 Expenditures on R&D in % of GNP**

University budgets for research come from the national government (60%), the Dutch Organization for Pure Scientific Research (15%) and contracts with industry (25%). The Netherlands targets about 15% of its total research capacity towards health care. Of this, 60% is carried out at universities, 20% in non-university institutes and 20% by industry. The quality of this research is considered outstanding. Many Dutch research groups enjoy an internationally leading position in their respective fields. Dutch scientists contribute close to 2% of the international scientific literature; an astounding figure considering the size of the country.

Specialized institutes and eight medical faculties associated with academic hospitals provide the main sites of medical research in The Netherlands. On a national scale, the complete spectrum of medical research is covered.
Figure 6 lists the country's areas of emphasis in the medical field, together with the particular strengths of the medical faculties at the eight universities. Emerging trends in health care have mandated a refocus of medical research. As a result, fields have been selected for additional funding. This will facilitate research into disorders that have a major impact on the quality of life and which also affect large numbers of the population, such as musculoskeletal and psychiatric disorders, respiratory diseases and gerontology.

Fig. 6 Biomedical technological research takes place at various companies, specialized institutes and eleven of the thirteen universities. Thanks to the strategic location of the technical universities and compactness of the country, various inter-university and other joint projects can easily benefit from specialized medical and technical input.

More technically-oriented biomedical research complements the medical work. This is accounted for primarily by the country's three technical universities. Since their medical technology programs are mainly determined by the profile of their technological research, these universities have a distinct identity. Their work includes high-quality research in such disciplines as micro-electronics, computer sciences, system design, materials technology, bio-informatics, biomechanics, ergonomics and product design. Biomedical engineers affiliated with the technical universities frequently collaborate with scientists at the medical faculties.
Thanks to the strategic location of the technical universities and compactness of the country, various inter-university cluster projects can easily benefit from highly specialized medical and technical input. Expertise within the technical universities is very accessible for all interested parties. Coordination centers provide information on research projects and organize a variety of introductory programs. The Inter-University Biomedical Technology Committee (IUO) facilitates accessibility of specialized know-how from all universities. This group interconnects representatives of the universities and of The Netherlands Organization for Applied Scientific Research (TNO).

Fig. 7
Centers of excellence in various medical fields. The figure depicts particular strengths of medical universities in various medical fields. The universities involved are:

- VU: Free U. of Amsterdam;
- UvA: U. of Amsterdam;
- U: U. of Utrecht;
- L: U. of Leiden;
- N: U. of Nijmegen;
- R: U. of Rotterdam;
- Li: U. of Limburg;
- Gr: U. of Groningen.

Fig. 8
Priority areas in medical technology at three technical universities. The three technical universities frequently collaborate with each other and with scientists at the medical faculties when performing technically-oriented biomedical research. They have a distinct identity, mainly caused by the profile of their technological research programs.
- At Twente University, emphasis is on biomechanics, biomaterials and bio-informatics;
- At Delft Technical University, priority areas are aids for the disabled and advanced imaging techniques and systems;
- At Eindhoven Technical University, special focus is on technology related to vital functions, perceptive information processing, hospital management and organization and gerontechnology.
Dutch research institutes make a considerable contribution to medical technological research. The Central Laboratory of the Blood Transfusion Service (CLB), The Netherlands Cancer Institute (NKI) and The Netherlands Institute for Health and Environmental Hygiene (RIVM) are internationally recognized as leaders in their respective fields of blood technology, oncology and vaccine development. The Royal Institute for Tropical Diseases (KIT) is respected for its development of diagnostic tools based on monoclonal antibodies. The Institute for Perception Research (IPO), founded by Philips and the Technical University of Eindhoven, is an outstanding center specialized in hardware and software related to perceptive information processing.

Among the research organizations, TNO enjoys a special position. TNO accounts for 50% of the nation's non-university health-care research. After a major reorganization in the beginning of this year, medical technological research is concentrated in one of the thirteen institutes. TNO is distinguished by its scope, the cooperation between its institutes, its collaboration with universities and its industry-oriented nature.

Dutch scientists both at universities and institutes increasingly participate in industrial research projects. This promotes an optimal use of medical and technical know-how. Due to the governmental financing system of the universities, the know-how is easily accessible at low cost. Since M.Sc. and Ph.D. students all have scholarships, their participation in research projects with industry is relatively cheap, when compared with other European countries.

![Fig. 9 Leaflet heart valve prostheses are being developed at Eindhoven University to replace porcine heart valves (top), currently used for implants. Finite Element Models are used in designing to overcome disadvantages of existing types.](image1)

![Fig. 11 A compact thermo-luminescence badge was developed for use in radiation protection studies, radiological safety and individual dose control by the Radiological Institute of TNO (Arnhem). Its international renown is shared by TNO's Radiobiological Institute.](image2)

![Fig. 12 Elbow orthosis developed at Delft University and used by hundreds of patients. To develop improved orthoses, a main goal at Delft, scientists employ three dimensional analyses of shoulder movements, CAD techniques and proprioceptive studies.](image3)
Fig. 13
Representations of successive helical axes during knee flexion are an aspect of extensive studies of joint kinematics at Nijmegen University. Results are reflected in the design of novel hip, knee and wrist prostheses. New prostheses from commercial suppliers can be tested with advanced equipment and models.

Fig. 14
A three-dimensional trunk motion analysis consists of an inclinometer and devices for flexion and torsion. It was developed at Rotterdam and Delft universities to study posture and movement during daily activities.

Fig. 15
Positron Emission Tomography is used at Groningen University to conduct pharmaceutical, tumor, and in particular, brain research. Graph shown is from work on the rate of protein synthesis in brain tumors. Groningen is well-known for studies of neurotransmitter phenomena related to Parkinson's disease.
Biomedical and Health Care Technology at the Eindhoven University of Technology

The Eindhoven University of Technology (EUT) considers it of great importance to maintain platforms for interdisciplinary research activities. The Center for BioMedical and Health Care Technology (BMGT), being one of them, initiates and coordinates activities in which fundamental science and technological expertise are applied to biological and medical problems.

The combined university faculties contribute to a total of over 75 man-years of research per annum in this particular area, resulting in, among others, an average of 50 M.Sc and 10 Ph.D-theses per year. As such, BMGT constitutes the largest multidisciplinary program of the university.

All faculties are represented in the steering committee of the Center BMGT. The center provides the general policy for this field. The Center office is responsible for corporate matters and acts as a gatekeeper and as an active interface between research, health care and industry.

Research groups have built up expertise in the fields of: human perception and interfaces, organization and management, indoor climate and architecture, biomechanics, physiological chemistry, electrical engineering in medicine, biophysics and physical measuring methods and human factors. With permission of Dräger International I can mention one illustrative example of a very successful collaboration between them and our group in medical electronics. The research on patient monitoring of this group has resulted in the design of an integrated work station. As of 1990 about 180 work stations were sold in the Netherlands and about 1500 worldwide. At a price range between 50.000 - 80.000 US$ this means a turnover of 100 million US dollars in 3 years. Present areas of growing interest are information ergonomics and gerontechnology.

Gerontechnology aims at the combination of, among others, technological and ergonomical factors that determine the quality of life and the capability of the elderly to remain independent. The objective of the gerontechnology program is the optimization of the functional environment of the elderly and the possible contribution of technology to this, given the reality of socio-cultural and economic constraints and opportunities.

Gerontechnology uses the ongoing research on aging processes as a reference for the definition of technological approaches to sustain functional independence and well-being.

Fig. 16  Functional performance x Age
The framework of the gerontechnology program consists of:

* The realization of a reference base, built upon more comprehensive insight in normal aging processes and the description of these processes with appropriate parameters
* Collection of qualitative and quantitative information regarding normal aging at the level of daily human functioning
* Collection of information with respect to the influence of environmental factors and of technical products, processes and systems on older consumers
* Development of operational user characteristics and standards in relation to the (technical) environment, i.e. human factors for the elderly
* Generation of design criteria and specifications for the total of technical products, processes and systems that can or will be present in the daily life of the elderly
* Initialization of projects, evaluation studies and processes of optimization and implementation.

Three main domains and their subsequent intermediaries are involved in the program, i.e. the consumer market, the industrial branches and the relevant academic research disciplines.

It is obvious that older consumers, especially, will remain independent and active in society on the premise that living and working environments are created and provided that support them in their activities of daily life. In order to achieve this it is necessary that products and services become available that have been proven to meet functional criteria for older users. As in the US, also in Europe, the people aged 50 and over account for 70% of the purchasing power.

The first international conference on gerontechnology in Eindhoven and its preceding survey made clear, that, until now, only scarce information has been gathered in a systematic way on the capabilities, limitations, activities and wishes of older consumers. It has also become clear that new products only very rarely have been evaluated in the actual user environment.

*Fig. 17 The arena of Gerontechnology*
The producers as well as the distributors of products and services are in need of more practical information and knowledge on consumer groups. Some problems are apparent here:

- Producers are not (yet) aware of their lack of knowledge
- They do not know where the knowledge is available
- The available knowledge is difficult to apply
- They do not know which knowledge is relevant for them.

Therefore a close collaboration program is organized between producers and distributors as one party and a network of knowledge centers as the other. Research centers form the nodes of this network, especially because of the assumed lack of insight in certain basic or fundamental processes of aging. A technological research center in Eindhoven is one of the nodes in this network. It's position is that of a linking pin between industrial product development and public services (the market) and the socio-economical and medical research.

In summary: The elderly do need technical products and services for their activities of daily life. However, the providers do not know which products and services are desired or appropriate. The market of the elderly is still judged as unattractive and many elderly do not know which products are available or how they can get access to them. Therefore, more consumer research, especially earlier product evaluation, needs to be carried out. On top of that, a consumer information system has to be established in another form as the actual information systems. Aspects, such as user friendliness, comfort, safety, efficiency and efficacy should be ranked as high if not higher than price, maintenance costs, technical performance of products, etc.

**Innovation Oriented research Programs (IOPs)**

The Dutch government supports R&D programs in those fields where innovative products with a high competitive value might result. In the domain of medical technology a number of IOPs have been or will be established. Among these are:

* medical imaging technologies
* biomaterials
* biomechanics.

A further analysis has to be made of the potentials of biomolecular and cellular analysis methods. The field of home health care technology is, together with gerontechnology, considered of great importance for society. It is still unclear which sectors of industry will play a dominant role in this arena, but a strong trend is noticeable towards Over The Counter(OTC) products in favor of products and services that are delivered through the medical system.

**Region II-status**

A final remark should be made with regard to the recently acquired region II-status of the region Eindhoven. This status means that all activities that might lead to new employment are largely subsidized by the EC and other governmental bodies. Industry involved in these projects only has to contribute 20% of the total project budget.
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