Medical Technology
– Generating innovative ideas and solutions

There will be an increased demand for services in future healthcare, thus focus on cost efficient patient treatment is essential. In an effort to meet future demand for high-quality patient treatment, new medical technology can be part of the solution. Medical technology offers patients improved well-being due to less invasive procedures and individually adapted treatments. NTNU contains some of the strongest communities within technology and medical research in Norway. When the six strategic areas at NTNU were evaluated in 2007 the conclusion was that taking advantage of the combined expertise in engineering, bioscience and medical research was an excellent move, which should be further developed and strengthened.

The strategic area Medical Technology aims to be the key arena for technology and medicine at NTNU, and to have an international impact as well. The new St. Olav's University Hospital is currently under construction in Trondheim, where we are integrating the university and hospital floor space. Our experience is that the university hospital facilitates productive interaction between researchers, clinicians, students from different faculties and engineers on a daily basis. We have experienced several important developments in technology due to the proximity between the Engineering and Medical School at NTNU and St. Olav's University Hospital. One result has been the development in ultrasound technology, and I am proud that we in 2007 established one of the few Norwegian centers for Research-based Innovation at our university in Ultrasound and MRI (Medical Imaging Laboratory for Innovative Future Healthcare, MI Lab). In May 2007 the biomechanics group, which is one of the small research groups in Medical Technology, signed a contract to be a formal partner in the Centre of Excellence "Center for Biomedical Computing" at Simula Research Laboratory in Oslo. 2007 was an exciting year for us in the strategic area Medical Technology, and we are really looking forward to continue all the projects we have started and to increase our impact internationally.

Stig Slørdahl
Dean at the Faculty of Medicine
Director of the Strategic Area of Medical Technology

International Evaluation of the Strategic Area
NTNU's six strategic areas were evaluated by international panels in 2007. The objective was to evaluate the NTNU Strategic Areas as an instrument for NTNU to achieve its goals as a university of highest scientific quality and societal relevance. The evaluation should identify scientific results achieved with a special focus on added value of the Strategic Area and assess whether the Strategic Area's organizational and financial circumstances were suited to promote its performance. The launching of coordinated activities on thematic areas of large importance in 1999 was expected to promote multidisciplinary teamwork between already highly competent research groups, in order to create knowledge and solutions for the society.

The evaluation panel for Medical Technology states that "... the creation of the Strategic Area Medical Technology has been an excellent move by NTNU to take advantage of the combined expertise in engineering, bioscience and medical research." Focus areas such as Medical Imaging, and sub areas such as Biomedical Optics are described as scientific excellent and world leading. The evaluation panel also particularly points out that integration of the research aspect into the clinical activity in the new university hospital is unique in a global perspective. This represents a potential for further developing the multidisciplinary cooperation between research, development and clinical application. The evaluation report gives valuable advice on how to further strengthen the strategic area both in means of scientific focus, organizational and strategically development. The overall evaluation of NTNU's strategic areas points out that changes in how the strategic areas are organized, allocation of resources and clearer objectives, are necessary to achieve the university's main goals. The strategic area will put effort in following up the recommendations of the report in the years to come.

Dr. Sibylle Reichert (middle front) headed the international star-team of evaluators.

Strategic Area Medical Technology

PhD degrees in Medical Technology 1992-2007

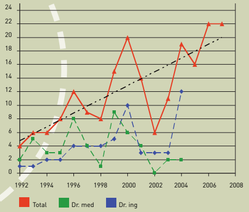


Table 1: PhD degrees in medical Technology.

The Strategic Area Medical Technology at NTNU includes:
- Medical Imaging
- Medical Biotechnology
- Bioinformatics
- Biomechanics
- Biomedical Optics
- Nanomedicine
- Health Informatics
- Operating Room of the Future
- Societal Aspects of New Technologies
- Medical Simulation Center

Research Management Team
- Dean, professor Stig Slørdahl (stig.slordahl@ntnu.no), director of Medical Technology
- Professor Catharina Davies (catharina.davies@ntnu.no), Faculty of Natural Sciences and Technology
- Professor Bjørn Skallerud (bjoern.skallerud@ntnu.no), Faculty of Engineering, Science and Technology
- Professor Toril N. Hernes (toril.n.hernes@sintef.no), SINTEF Health Research
- Professor Thomas Tybell (thomas.tybell@iet.ntnu.no), Faculty of Information, Technology, Mathematics and Electrical Engineering
- Associate professor Aksel Tjora (aksel.tjora@svt.ntnu.no), Faculty of Social Sciences and Technology Management, and Faculty of Arts
- Professor Gudmund Marhaug (gudmund.marhaug@stolav.no), St.Olavs Hospital, Trondheim University Hospital

Network Team
- Professor Berit Johansen (berit.johansen@bio.ntnu.no), Medical Biotechnology
- Professor Finn Drabløs (finn.drablos@ntnu.no), Bioinformatics
- Professor Olav Haraldseth (olav.haraldseth@ntnu.no), MI Lab
- Associate professor Arild Faxvaag (arild.faxvaag@ntnu.no), Health Informatics
- Professor Hans Olav Myhre (hans.olav.myhre@stolav.no), The Operating Room of the Future
- Associate professor Aksel Tjora (aksel.tjora@svt.ntnu.no), Societal Aspects
- Professor Toril N. Hernes (toril.n.hernes@sintef.no), Center of Competence for 3D Ultrasound in Minimally Invasive Surgery
- Researcher Lise Randeberg (lise.randeberg@iet.ntnu.no), Biomedical Optics
- Professor Petter Aadahl (petter.aadahl@ntnu.no), Medical Simulation Center
- Professor Bjørn Skallerud (bjoern.skallerud@ntnu.no), Biomechanics
- Associate professor Pawel Sikorski (pawel.sikorski@ntnu.no), Nanomedicine

Coordinator, PhD Karin Tømmerås (karin.tommeras@ntnu.no)

Visit us at
http://www.ntnu.no/medtek (Norwegian) or
http://www.ntnu.no/medtech (English)

Strategic Area Medical Tehcnology
NTNU
Medical Technology Research Centre
N-7489 Trondheim
Tel: 73 59 88 59
Fax: 73 59 88 65

www.ntnu.no/medtech

Annual Report 2007 Strategic Area Medical Technology

Medical Technology

NTNU
Norwegian University of Science and Technology

Medical technology research award to Husebye and Halaas

In 2007 the Medical Technology Research Award was granted to Harald Husebye and Øyvind Halaas from the Department of Cancer Research and Molecular Medicine, based on their publication entitled "Endocytic pathways regulate Toll-like receptor 4 signaling and link innate and adaptive immunity" (EMBO J 2006;25(4):683-92). The work has made a great contribution to the understanding of molecular mechanisms underlying the immune response through Toll-like receptor 4.

The two price winners, Øyvind Halaas and Harald Husebye receiving the award from Pro-Rector of Research and Innovation at NTNU, Astrid Lægreid. Photo: Thor Nielsen/NTNU Info

MEDICAL BIOTECHNOLOGY

Researchers within the Medical Biotechnology area made in 2007 major contributions to the molecular understanding of disease within cancer, infectious and inflammatory diseases. Moreover, new targets for therapeutic intervention were discovered, and technology enabling genetic manipulation of model organisms was developed. For one such technology, a vector system for selective target gene knock out, the successful negotiations for commercialisation by the international company Sigma Aldrich, was concluded. In addition, five novel technologies were reported to NTNU Technology Transfer, and one patent application was submitted.

Technoport Awards 2007 – Prize winners in Medical Technology

For the second time since 2005, Technoport was arranged in Trondheim, Norway's capital of Technology. At this event technology-related prizes are awarded to focus on the people behind the technology and new technological innovations.

The Technoport Festival has been arranged biannually to celebrate and present progress within advanced technological development and the application of technology. The festival is a combination of conferences, workshops, exhibitions and events.

In 2007 researchers from the strategic area of Medical Technology were awarded two of the Technoport Awards. Professors Bjørn Angelsen and Hans Torp were awarded the NTNU and SINTEF Technology Prize for their long term contribution within the area of ultrasound technology development. Both are members of the Medical imaging network group. Researcher Lise Lyngsnes Randeberg received the Young Innovators Award for development a product that dates skin bruises, and which may help solve murders and assault cases more quickly. Randeberg is part of the Biomedical optics network group.

Health Informatics

The Health Informatics Programme is a joint research programme between the strategic areas of Information and Communication Technology (ICT) and Medical Technology. The main focus of the programme in 2007 is the Norwegian Centre for Electronic Patient Records (NSEP) and its unique usability laboratory where up to three ward rooms can be set up for experimental development of mobile health-it systems. The usability lab has become a national test bed for both commercial-grade and experimental, research based health-ICT systems. In 2007 an all-time-high number of PhD students have completed their PhD.

Together with SINTEF and Operating Room of the Future, NTNU health informatics has been awarded approximately 20 MNOK research grant for a project entitled "Co-operation Support Through Transparency" (COSTT). The Health Informatics Programme has also developed a master's programme in health informatics tailored to the needs of healthcare and ICT-personnel already working within the domain.

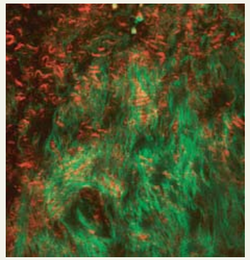
NANOMEDICINE:

In order to increase the strategic focus on bionanotechnology/nanomedicine the Strategic Area Medical Technology started in 2007 a network in nanomedicine.

The main focus during 2007 has been strategic development of the area, including focus on how to equip the forthcoming NTNU NanoLab in order to optimize the research possibilities within nanomedicine at NTNU. A workshop on bionanotechnology with participants from both NTNU and SINTEF was arranged to create a fellow team spirit and to coordinate future activities. Current and future bionanotechnology research at NTNU was identified and the most important areas include theranostics, sensors, and bioactive surfaces.

Biomedical Optics

Detection of cardiovascular disease



One of the most dangerous features of arterial plaques is that they can rupture, obstruct the vessel, and cause a sudden heart attack. Being able to detect plaques likely to rupture is of great clinical interest.

The topmost structure of plaques (the cap) consists mostly of collagen and can be imaged and detected with multiphoton microscopy (MPM) using second harmonic generation. One of the features which render plaque unstable is a thin cap. Due to the three-dimensional sectioning capability of MPM we can also use this technique to measure the thickness of the plaques, characterizing one of the most important features of vulnerable plaques.

Lilledahl MB et al. Characterization of vulnerable plaques by multiphoton microscopy. J Biomed Opt. 2007;12(4):044005.

Collagen fibers (red) and elastic fibers (green) imaged using second harmonic generation and two-photon excited fluorescence, respectively.

SOCIETAL ASPECTS OF NEW TECHNOLOGIES

With new medical technologies, economic reforms and emphasis on the patient role as active and participative, there is a fair chance that today's patients may be different than yesterdays. On basis of research within the social sciences, 15 contributors reflect critically in the new edited book "The Modern Patient" (Gyldendal akademisk, edited by A. Tjora) about how patients relate to health, illness, and health services. The interdisciplinary approaches to medical technology have provided an important background for the reflection of the modern patient.

Medical Imaging: New MR method for improved head trauma diagnosis

Severe head trauma causes a gradual loss of brain connections, called diffuse axonal injury, also in areas distant to the impact site. This causes no functional impairment, but the patients suffer from problems like irritability, apathy, depression and slow brain function in general. There is limited knowledge about the cause of this condition, and no established therapy or diagnostic method to neither localize the damage nor monitor the development.

At the MR Centre in Trondheim the fMRI group managed by associate professor Asta Håberg recently showed that quantitative diffusion tensor imaging is a potential new method for this purpose. This was mainly carried out by medical student researcher Jian Xu and published in the internationally most prestigious journal for head trauma research.

In a group of chronic head injury patients a pattern of reduced connectivity in several major white matter tracts were found, and this was in accordance with previous knowledge about the most common sites for diffuse axonal injury. The method has a practical potential as a diagnostic tool to identify as early as possible the patients that should receive intensive rehabilitation programs. The method is also promising as a clinical research tool to generate new knowledge about the cause of the disease and for discovery of potential therapeutic targets.

Xu J et al. Diffuse axonal injury in severe traumatic brain injury visualized using high-resolution diffusion tensor imaging. J Neurotrauma 2007;24:753-65.

The corpus callosum (main brain connections between the two hemispheres) in a healthy volunteer (left) and a head trauma patient with diffuse axonal injury of medium severity (right).

Operating Room of the Future (ORF)

Operating Room of the Future (ORF) is a resource centre for future integration and implementation of new technology and instruments in hospital operating areas. In 2007 altogether 70 groups visited ORF, of which 31 were international and represented 26 different nationalities. One PhD-degree, two Master degrees and three Bachelor degrees were finished in 2007 and six PhD-projects are under preparation. The focus is navigation in laparoscopic and endovascular therapy, stentgraft with sidebranches, strain for evaluation of rupture risk in aortic aneurysm, characterisation of atherosclerotic plaques and ultrasound imaging of blood flow for intraoperative control. Dyna-CT is evaluated as adjunct during stentgrafting for aortic aneurysms. Other projects in laparoscopic surgery are the treatment of morbid obesity, the application of navigation within laparoscopic surgery and the application of HD-transmission in teaching of specialist candidates.

New St. Olav's Unversity Hospital under construction June 2007

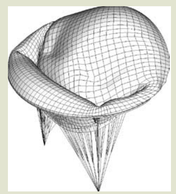
THE MEDICAL SIMULATION CENTRE

The Medical Simulation Centre has constructed a portable simulation center for on-site simulation. This makes it possible to carry out training in advanced emergency medicine in facilities both inside and outside the University Hospital.

Biomechanics

Improved physiological understanding of the mitral apparatus

The mitral valve, located between the left atrium and left ventricle of the heart, prevents blood from flowing back into the atrium during systole. Hence, it is of utmost importance for the circulation and health. Diseases related to the mitral valve often occur in the population. However, the detailed understanding of its function, both under healthy and pathologic conditions, is not yet established. To remedy this, advanced porcine studies have been carried out, where 3D ultrasound, morphology, mathematical modelling of the biological materials, and numerical simulations have been combined. An anatomically correct geometry of the valve has been analysed, using 3D finite element simulations. The relative importance of the chordae tendinae in carrying the heamodynamic load on the leaflets has been established. Furthermore, the importance of leaflet thickness and annulus shape have been quantified. This study has focused on healthy objects, and will be followed up by investigating effects of diseased tissues in the valve.



Prot V, Haaverstad R, Skallerud B. "Finite element analysis of the mitral apparatus: annulus shape effect and chordal force distribution". J Biomechanics and Modeling in Mechanobiology. (DOI 10.1007/s10237-007-0116-8).

The shape of the mitral valve at peak systole, predicted with nonlinear finite element analysis.

Bioinformatics

The research group for Bioinformatics & Gene Regulation at the Faculty of Medicine developed in 2007 new computational tools for research on gene regulation, in particular for studies on microRNAs, transcription factors and promoter regions. These new tools outperform all comparable tools. They are important for understanding the structure of our genome and how that affects our genetic profile and disease risk. The research has identified unique physical properties of DNA in gene start regions. This is used for identification of new genes, in particular genes that do not produce protein as the end product.
For more information see: **http://tare.medisin.ntnu.no/**

NATIONAL CENTRE FOR 3D ULTRASOUND IN SURGERY

The national centre aims to improve patient therapy by use of ultrasound and navigation in neurosurgery, vascular surgery and laparoscopy.
In laparoscopic surgery, the manipulation of the surgical field, limited access through small incisions with rigid instruments, and reduced free sight, dexterity, and tactile feedback make the procedure challenging. In 2007, the National Centre for 3D Ultrasound presented results from the first pilot studies using a self-developed navigation platform for improved image guided laparoscopic procedures. In the publication "Navigation in laparoscopy – Prototype research platform for improved image-guided surgery" in Minimally Invasive Therapy 2008;17:1, navigation technology, software and methods used in pilot studies are described. The initial results using this technology with preoperative images and guidance in the retroperitoneum during laparoscopy are promising.