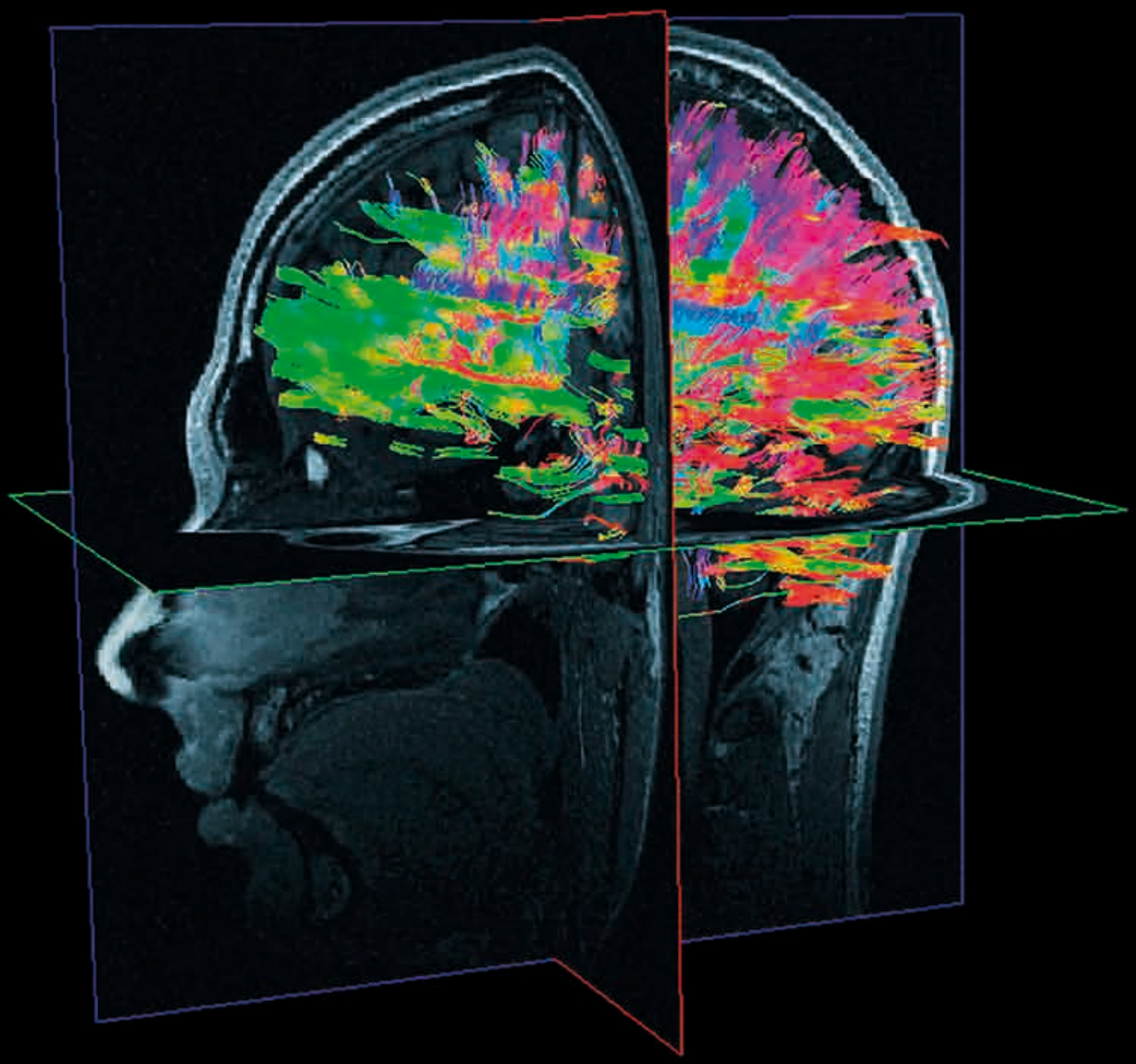


# Annual report 2008

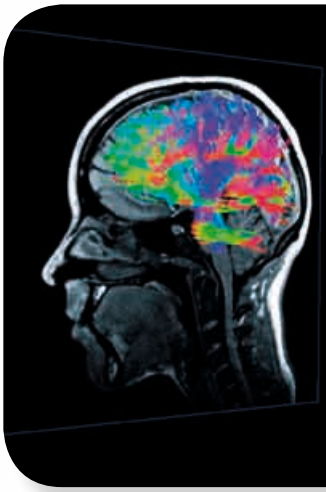
## The Interventional Centre

Rikshospitalet University Hospital

# ANNUAL REPORT 2008

## The Interventional Centre






ANNUAL REPORT 2008

More information at the web pages: *www.ivs.no*

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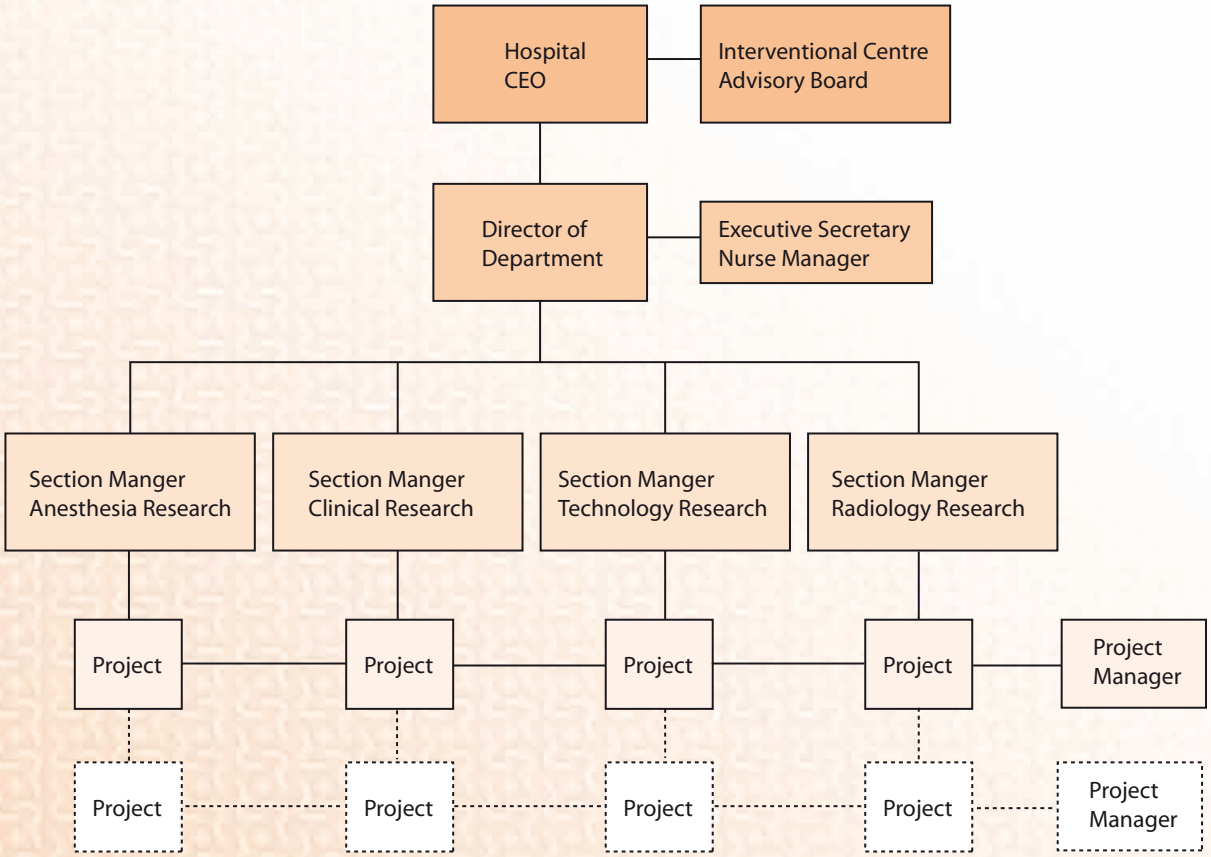
# Organisation

## THE INTERVENTIONAL CENTRE 2008
## RIKSHOSPITALET UNIVERSITY HOSPITAL




# The Interventional Centre – new technologies

During 2007 most of the heavy imaging technology at the Interventional centre was changed. The open, interventional magnet was removed, and a 3T high field MR from Phillips was installed. The seven year old angiographic system was also removed and the Interventional centre started a collaboration with Siemens to develop the Zeego system for an OR environment. Thus 2008 started with projects in two completely new systems.

The 3T magnet was provided both for imaging research and for intraoperative MR imaging. The magnet was acquired in collaboration with the Institute for Psychology, and this collaboration proved very fruitful. Studies of functional imaging of the brain were performed from the first day. The department of neurosurgery and the ENT department started using the MRI for intraoperative imaging during scull base surgery. The magnet was also used in numerous animal studies. Thus the number of procedures in the magnet was quadrupled by the introduction of the new MRI technology. And the investment that was made possible by collaboration between the hospital, the University of Oslo and the Norwegian Research council proved a great scientific success during 2008.

Imaging by the new Zeego angiographic equipment also started in January 2008. By using the system in the OR environment where several advanced procedures were performed, the system was thoroughly tested. After only a few months, Siemens concluded that major changes had to be made in the system to make an optimal clinical installation. Thus the system was removed, and a completely new system was installed in the autumn 2008. And the improved system was made availably for commercial use.
The reach of the robotic arm of the Zeego system made it necessary to remove the OR lamps in the ceiling. The Interventional centre then developed a new system for OR light together with the company Artlight. The system was named "Lightor" and is still under development.

The high activity in the ORs following the change in equipment demonstrates the increasing importance for advanced imaging in the treatment of patients. In our third OR the number of advanced endoscopic procedures also continued to increase. Interventional bronchoscopy and advanced laparoscopy reached record levels in 2008. Laparoscopic liver surgery and pancreas surgery are now established methods at our hospital.

The increased activity in the ORs was matched by an increase in publications and scientific works. Several new ideas were also patented in 2008, and a number of small companies approached us for development of their ideas. The Interventional centre is a tool box for clinicians and scientists in our hospital as well as for others. We look forward to more scientific collaboration in the years to come.

Erik Fosse
*Head of Department*

# The Interventional Centre

## MAIN GOALS AND OBJECTIVES

The Interventional Centre is a research and development department for image guided and minimally invasive therapy at Rikshospitalet University Hospital (RH-HF) in Oslo.

**The Interventional Centre has the following tasks:**

1. Development of new procedures.
2. Development of new treatment strategies.
3. Compare new and existing strategies.
4. Study the social, economic, and organisational consequences of new procedures on health care.

## STRATEGY

The Interventional Centre shall be a research and development resource for all the clinical and laboratory departments at Rikshospitalet University Hospital.

The Interventional Centre shall actively offer similar services to the healthcare community in Norway outside the hospital.

The Interventional Centre shall work as a link between technology institutions (commercial and academic) and the clinical medical environment in the hospitals.

The Interventional Centre shall promote and work actively to protect new knowledge and facilitate commercial exploitation.

**The research is focused in four strategic areas:**

1. MR guided intervention and surgery.
2. X-ray, CT, ultrasound, video-guided interventions and surgery.
3. Robotics and simulators.
4. Biosensors, data management and communication.

## DELIVERIES

**The Centre delivers the following:**

1. New clinical methods.
2. Research.
3. Intellectual property/innovation.

## ORGANISATION

The Interventional Centre is an independent hospital department. The Head of department reports directly to the hospital CEO. A National Advisory board with representatives from all universities and university hospitals in Norway and the main departments at Rikshospitalet monitors and gives advice on research and activity. In 2008 the Interventional Centre had a cross-disciplinary staff of 24 employees. Seven doctors, nurses, radiographers and engineers employed by other departments worked regularly at the Centre while a large number of medical staff from most departments in the hospital worked at a less regular basis at the Centre. There were three university-employed professors ( *Erik Fosse, Tor Inge Tønnessen* and *Tor Edvardsen* ) at the Faculty of Medicine, University of Oslo, one professor at the Department of Informatics, University of Oslo ( *Eigil Samset* ) and one professor from the Department of Electronics and Telecommunication at the Norwegian University of Science and Technology ( *NTNU* ) in Trondheim ( *Ilangko Balasingham* ). Professor Atle Bjørnerud from the Department of Physics, University of Oslo established his research group at the Centre in 2006. In addition 20 scientists were working at the Centre by external funding.

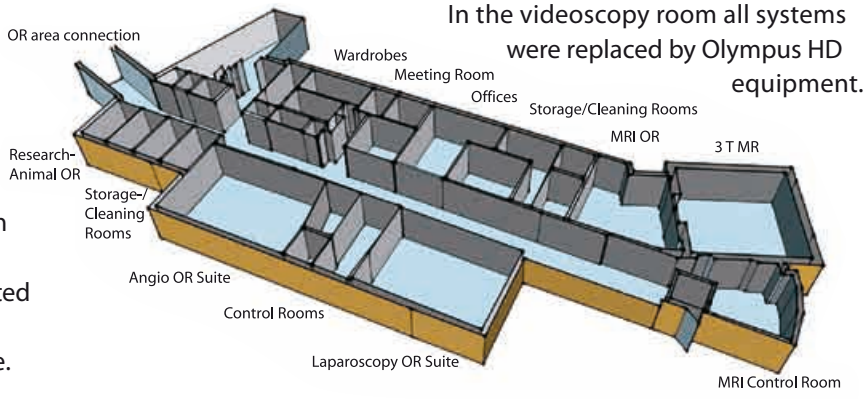
## MATRIX ORGANISATION

In order to facilitate effective execution of cross-disciplinary projects, the personnel and equipment at the Centre were allocated to four sections in a matrix organisation *( illustrated in the figure on page 4 )*. Each section is headed by a section manager. Each project has a project manager and the project manager reports to the section manager in charge of the project. The head of department and the section managers constitute the management group where new projects are approved. Both the equipment and the staff are available as a common resource for departments and research groups aiming at developing and quality assess new methods. Scientists/clinical departments outside the Centre were responsible for a substantial number of the projects run in 2008. 40% of the staff had a technological, non-medical background.

By the end of 2008 the employees of the Interventional Centre came from 13 different nations all over the world. The Interventional Centre thus represented a unique multi-national environment of medical and technological expertise.

## FACILITIES

The Centre has a unique architectural structure. In the three suites advanced imaging equipment was integrated in an operation room environment. In 2008 all advanced imaging equipment was renewed. In the combined surgical and radiological suite, the conventional angiographic equipment was substituted by the Siemens Zeego system, based on robotic technology and containing new advances in imaging and functionality. Our MRI suite was completely rebuilt into a dual room suite where a 3T was installed in one room beside a state of the art OR. The two rooms were separated by a sliding door, allowing surgery with standard equipment and intermittent MRI imaging. In the videoscopy room all systems were replaced by Olympus HD equipment.



# Research Groups

## ENDOBRONCHIAL PROCEDURES

*Arve Sundset, MD*

This is a national program for interventional bronchoscopy and treatment of airway lesions. The program includes patients with lung cancer obstruction, with benign airway stenosis, and patients with airway complications following lung transplantation.
This program also includes of EBUS-TBNA *(endobronchial ultrasound-guided transbronchial needle aspiration)*, a novel method of mediastinal staging in lung cancer, and diagnostic fine needle aspiration of mediastinal disease.

**Two PhD studies related to the program are in progress:**

1. PhD. research fellow: Kirill Neyman is studying survival and quality of life following interventional bronchoscopy in patients with inoperable lung cancer.
2. PhD. research fellow: Arve Sundset is studying airway perfusion in lung transplant recipients, and treatment of ischemic airway complications following lung transplantation.

## ADVANCED MR NEURO IMAGING

*Professor Atle Bjørnerud, PhD*

The main focus of the Advanced MR Neuro Imaging (AMRNI) group is in the development of novel MR-based imaging techniques and software tools for improved diagnosis of brain tumours and neurodegenerative disease.

The AMRI group currently employs 2 PhD students *(one in collaboration with the MI lab in Trondheim)*, 1 software engineer *(by mid 2009)* and 2 PostDocs *(by mid 2009)* in addition to the group leader.

In brain tumour diagnosis, the group has initiated major projects supported by the the Norwegian Research Council and Helse Sør-Øst. The latest project, named Evaluation of functional Magnetic Resonance in the Diagnosis of Brain Tumors for Assessment of Clinical Efficacy *(EMBRACE)* will aim at providing better initial diagnosis and follow-up *(for optimal therapy planning)* in patients with intracranial tumous. This is a multidisciplinary project run by the AMRNI group, but involving both physicists, software engineers, neurosurgeons, neuroradiologists and pathologists as well as collaboration with groups in Germany and the US.

The group has to date received about 15 MNOK in research grants for brain tumor related projects. The project members submitted 2 patent applications and produced 5 peer-reviewed articles and one book chapter in 2008 in addition to a substantial number of conference presentations and invited lectures.

AMRI group also provides clinically relevant Masters Degree projects for students majoring in biophysics and informatics and currently supervise 3 MSc projects related to advanced neruoimaging methods *(diffusion tensor imaging, quantitative MRI and dynamic contrast enhanced MRI)*.

The AMRNI group is also heading up the imaging part of a MR/PET project called Go/MCI which is part of the MedCoast program. The main objective of the Go/MCI

project is to find new bio/imaging markers for vascular dementia and Alzheimer's disease.

The AMRNI group is further involved in many MR-projects where our main focus is on MR sequence optimization and data handling. The group has also developed a large image processing software system *(called nordicICE)* in collaboration with a Bergen-based company *(NordicImagingLab)*. The software system has been fully integrated into the hospital PACS system and has become an important clinical tool for advanced analysis of MR images.

## IMAGE GUIDED GENERAL SURGERY AND INTERVENTION

*Section manager Bjørn Edwin MD, PhD*

Several new techniques in laparoscopic surgery have been introduced in Norway through this group. Some of the methods are now routine procedures, like laparoscopic adrenalectomy and laparoscopic prostatectomy. The group validates new procedures and establishes effective training. One multi-centre study on the quality of laparoscopic colonsurgery is finished in 2008. A randomized study between laparoscopic and open liver surgery is designed and should start in 2009.

Education programs in minimal invasive surgery in both gastrointestinal- and urological surgery are organized in collaboration with other hospitals in Norway, Sweden, Russia and Denmark.

**The Department of Surgery is one of our main collaborators with research projects ongoing in:**

- Minimal invasive surgery on the liver, pancreas, stomach, esophagus, kidney, adrenal gland and colon/rectum.
- Minimal invasive techniques in children.
- Thermal liver ablation.

So far three medical dissertations have been completed and two programs were ongoing in 2008.

**Ongoing PhD programs in 2008:**

1. PhD. research fellow: Airazat M. Kazaryan M.D.: *Extracorporeal high intensity focused ultrasound ablation of liver malignancies.* Mentors: Bjørn Edwin, M.D., Ph.D., Erik Fosse, M.D., Ph.D. Rikshospitalet, University Oslo.
2. Ph.D. research fellow: Martin Johansson: *Percutaneous access and connection to visceral organs.* Mentors: Peter Thomsen M.D., Ph.D., Instutition för kliniske vetenskaper Gøteborgs Universitet, Bjørn Edwin M.D., Ph.Dn., Interventionssenteret Rikshospitalet Oslo, Leif Hulten M.D., Ph.D., The ColoRectal Unit Sahlgrenska University Hospital.

## IMAGE PROCESSING, VISUALIZATION AND NAVIGATION

*Professor Eigil Samset, PhD*

Most minimally invasive procedures restrict the access and direct vision to the regions which require surgery. Such procedures require intra-operative image modalities such as ultrasound or endoscopic images to be able to monitor the surgery. In many cases this information is not sufficient to perform the procedure accurately and safely. Merging information acquired pre-operatively, mainly from for instance MRI, CT or PET, with intra-operative data can increase the basis for decisions and thereby improve the safety and accuracy of the procedure.

The image processing, visualization and navigation group develops cutting edge technological solutions which support minimally invasive procedures. As the title of the group indicates, the research focus is divided into three areas. Image processing methods are key elements in any software system which supports minimally invasive procedures. In particular, we are focused on developing real-time image-segmentation and – registration methods where segmentation methods finds important anatomical structures such as tumours and vessel structures in images, while registration methods enables fusion of images.

Visualization and navigation is required to present the medical images to the surgeon intra-operatively. We are developing visualization systems which use advanced techniques such as augmented reality and volume rendering for this purpose.

**The group had 5 ongoing PhD programs in 2008:**

1. Tangui Morvan (ARIS*ER- Early stage researcher): *Development of general purpose algorithms for collision detection using GPU (Graphics Processing Unit).* Mentors: Eigil Samset, The Interventional Centre and Martin Reimers, Department of Informatics, University of Oslo.

2. Sergiy Milko (ARIS*ER Early stage researchers): *Automatic registration of Ultrasound and CT/MRI images.* Mentors: Prof. Eigil Samset, The Interventional Centre and Timor Kadir, Siemens Magnet Technologies.

3. Petter Risholm (MATMED PhD student): *Intra-operative deformable registration.* Mentor: Prof. Eigil Samset, The Interventional Centre.

4. Eivind Lyche Melvær (MATMED PhD student): *Reconstruction of 3D images from free-hand 2D ultrasound.* Mentors: Prof. Knut Mørken, CMA/UiO and Prof. Eigil Samset, The Interventional Centre.

5. Egil Bae (MATMED PhD student): *Image Segmentation and Reconstruction using level sets and graph cuts.* Mentors: Prof. XueCheng Tai, CIPR/UiB and Prof. Eigil Samset, The Interventional Centre.

## ARIS*ER AUGMENTED REALITY IN SURGERY

*Professor Eigil Samset, PhD*

ARIS*ER is a Marie Curie Research Training Network funded by the EU and aims at developing an augmented reality system supporting minimally invasive procedures. Advanced methods for image processing and visualization for improved RF-ablation was also developed and tested during several user studies.

**Other important research results which originate from ARIS*ER are:**

- Methods for fast and reliable image segmentation of liver structures.
- Visualization tools which enables information filtering.
- Novel navigation tools which improve targeting during needle insertion.
- New methods for performing requirements engineering.
- Methods for registration of MR and US.

A demonstrator that incorporates the different general technology features are developed to communicate with the clinicians. The ARIS*ER research group has in total 8 PhD-programs and 5 Post-docs employed by the 8 different European academic and industrial partners.

## MATMED

*Professor Eigil Samset, PhD*

The project "Mathematical and computational methods for co-registering multi-modal medical images" (MATMED) is funded under the eScience program at the Norwegian Research Council for the period 2007-2011. It is a joint project between the Interventional Centre, Centre for Mathematics and Applications (CMA) at UiO and Center for Integrated Petrolium Research at the University of Bergen and funds three PhD positions.

In 2008 MATMED produced a video-presentation, aimed at increasing the awareness of mathematics to highschool and undergraduate students. The video is available from *www.matmed.no*.

## IMAGE GUIDED CARDIAC SURGERY AND INTERVENTION

*Section manager Jacob Bergsland, MD*

The heart group is in the process of developing multiple new programs, in the area of treatment and follow-up of cardiac patients. After keeping a strong research focus on beating heart coronary surgery, the Interventional Center is increasingly focusing on projects related to the new exiting area of endovascular cardiovascular therapies and minimally invasive monitoring of cardiac function.

**Aortic valve implantation through the endovascular route**
A pilot study will be started in the near future to establish both the transfemoral and transapical route for implantation of aortic valves. A large randomized study, focusing on short and long-term outcomes as well as cost benefit and life quality studies. The project is a cooperative project between cardiology and cardiac surgery departments within Oslo University Hospital and several other groups which will focus on the cost issues and studies related to quality of life.

**Pulmonary valve implantation in patients with congenital heart disease**
A highly successful project of pulmonary valve implantation in patients with poor function of the pulmonic valve has been initiated in cooperation with specialists from Rikshospitalet departments for cardiac surgery and cardiology. Long term life quality studies and cost are being performed. This program follows a successful development of various procedures at IVS for congenital heart disease; several of these have been successfully transferred to the interventional cardiology service.

**Heart sensor projects** have been a focus area for IVS for a number of years. At present several experimental and clinical projects are ongoing.
A three dimensional accelerometer, patented by IVS is being tested out for possible commercial use after the feasibility of detecting abnormalities in heart motion due to ischemia has been demonstrated. Several PhD degrees are related to these devices.
Similar research is ongoing using implantable ultrasound probes, the early results are encouraging.
The CO2 sensor developed at the IVS has also been tested experimentally as a monitor of ischemia of the heart as well as in other organs.

**The Ultrasponder project**
is funded by EU and is an exiting study where IVS cooperates with multiple investigators within EU countries.
The project which originates from the IVS engineering group will develop wireless sensors for use in patients with heart failure with the purpose of improving management of this very challenging group of patients which rapidly increase in size.

**International cooperation in clinical medicine**
IVS and affiliated groups continue to have government funded programs to assist in the development of the health care systems in countries in transition and other less fortunate countries. There are ongoing programs in Bosnia and Herzegovina and Palestine.

**Ongoing PhD programs in 2008:**
Cand. Med. Jacob Bergsland:
*Safe Introduction an quality control of new methods in coronary surgery.*
Mentor: Erik Fosse, the Interventional Centre/RR-HF.

## MEDICAL SENSORS

*Professor Erik Fosse, MD, PhD*

The Interventional Centre is co-ordinating a joint project called "Micro-Heart" for detection of motion changes of the heart surface. The goal is to develop a system for early detection of ischemia through continuous per- and post-operative monitoring using a 3-axis accelerometer for patients undergoing coronary revascularization *(Patent number: NO 20016385)*. The "Micro-Heart" project is a close collaboration with Vestfold University College in Tønsberg. The Interventional Centre is responsible for the clinical research activity, and both an animal study and a human study are ongoing to verify the sensitivity and specificity of the detection method. Vestfold University is responsible for miniaturizing a three-axis accelerometer for incorporation into a temporary pacemaker electrode. The project is partly financed by the Research Council of Norway *(NRC)* with 4 PhD scholarships at Vestfold University College.

Together with the Department of Clinical Engineering, professor Sverre Grimnes this group was also involved in the development of a sensor for measuring the sweat production in different parts of the body by a bio-impedance technique.

1. Cand. Med. Steinar Halvorsen:
   *Basic and clinical studies on cardiac ischemia by biosensors.*
   Mentors: Erik Fosse and Tor Inge Tønnessen, the Interventional Centre/Dept of Anaesthesiology, RR-HF.

2. Stud med. Gaute Gjein:
   *Evaluation of patients with hyperhidrosis.*
   Mentor: Erik Fosse, the Interventional Centre, RR-HF.

3. Christian Trondstad.
   *Development of a sensor for sweat measurement.*
   Mentor: Sverre Grimnes, dept of Clinical Egineering.

## BIOSENSORS

*Professor Tor Inge Tønnessen, MD, PhD*

The Biosensor research group has three main branches of interest, namely the biologic basis for ischemia and the choice of parameters for detection thereof, the second is the development of a specific pCO2 sensor and the third is developing methods for early detection of rejection in transplant patients. The biologic basis has been studied through animal experiments. Concerning the development of the sensor IscAlert™, we have collaboration with Alertis Medical AS and Memscap AS. The IscAlert sensor has received CE mark and FDA approval. In 2008 we have focused on developing the sensor for cardiac applications peri- and postoperatively. Experimental ischemia induced by occlusion of LAD is detected within minutes and IscAlert has 100% sensitivity and 100 % specificity after 4 min of ischemia. In an ongoing clinical study we put microdialysis catheters in patients undergoing liver transplantation, two catheters in the liver and one catheter subcutaneously has been finished. Every hour metabolic parameters of ischemia were measured and every four hours we collected analyses for measuring cytokines and complement factors for detection of rejection. We found that the method has the ability to detect ischemia caused by thrombosis of the hepatic artery, and that an increase in IL-8, IP-10 and C5a detects a rejection of the liver 2 - 4 days earlier than methods currently used.

1. Cand. Med. Lars Wælgaard:
   *New clinical methods for detection of ischemia*
   Mentor: Tor Inge Tønnessen, the Interventional Centre/Dept of Anaesthesiology, RR-HF.

2. Cand. Med Søren Pischke:
   *Biosensors for detecting cardiac ischemia.*
   Mentor: Tor Inge Tønnessen, the Interventional Centre, Dept of Anaesthesiology, and Tom Eirik Mollnes, IMMI.

3. Cand. Med. Håkon Haugaa:
   *Microdilaysis monitoring in transplanted patients.*
   Mentor: Tor Inge Tønnessen, the Interventional Centre, Dept of Anaesthesiology, and Tom Eirik Mollnes, IMMI.

## PATIENT COMMUNICATION

*Professor Erik Fosse, MD, PhD*

As part of a program to make the journal available to the patients, a program for automatic translation of medical terms into common Norwegian is being developed. One master thesis has so far been completed in this project.

## ORGANISATION

*Professor Erik Fosse, MD, PhD*

The Interventional Centre co-operated with the Institute for Informatics and The Institute for Health Management and Health Economics at the University of Oslo, as well with the Norwegian School of Management *(BI)* in a research project focusing on the relationship between innovation, learning, technology and organizational change processes.

**One PhD project was running as part of this program in 2008.**

1. Cand. Polit. Bjørn Erik Mørk:
   *Organising for learning and innovation in Norwegian hospitals – How new technologies challenge existing organizational structures and cultures.*
   Mentors: Erik Fosse, the Interventional Centre, RR-HF, Johan Olaisen, Norwegian School of Management Oslo, Terje Hagen, Institute for Health Management and Health Economy, University of Oslo.

## RADIOLOGY RESEARCH AND IMAGE GUIDED INTERVENTION

*Section manager Per Kristian Hol, MD, PhD*

A number of research projects using the 3 T MR scanner or the combined angiographic suite are performed in corporation with different academic partners, including Stavanger University Hospital, The Paediatric Research Institute, Departments of Neuropsychiatry and Psychosomatic Medicine, Oncology, Ear Nose and Throat, Neurosurgery, Neurology, Anaesthesiology and Radiology. The research topics cover brain, spine, liver, prostate, brachial plexus and inner ear. Programs for using the Flat-detector Computed Tomography technology of the angiographic system, for guidance of the insertion Cochlear Implant Electrode and for brain perfusion studies are under preparation.

**Main projects:**

- Preoperative MR of patients with prostate cancer.
- MR assessment of Intracranial Pulsatility and Cardiac-beat Intracranial Volume change.
- Intra-annular Radiofrequency Thermal Disc Therapy.
- Vasculo-interstitial Thermotherapy.

**A total of 4 PhD programs used the angiographic suite or the MR scanner for their research in 2008:**

1. Cand. Med. Charlotte de Lange:
   *Detection of organ injuries after hypoxia and resuscitation. An experimental study in piglets.*
   Mentors: Berit H. Munkeby and Ola D. Saugstad, Pediatric Research Institute.
2. Cand. Med. Trygve Kjelstrup:
   *Axillary plexus block, nervestimulator, ultrasound and MRI.*
   Mentors: Øivind Klaastad and Harald Breivik, Department of Anaestesiology/the Intenventional Centre, Albert Castellheim, Department of Anaesthesiology, Diakonhjemmet Hospital.
3. M.Sc. Håvard Kalvøy:
   *Bioelectrical properties of needle electrodes and human tissue, spatial and temporal dependencies.*
   Mentors: Sverre Grimnes and Ørjan G. Martinsen, Institute of Physics, University of Oslo.
4. Cand. Med. Torbjørn Elvsåshagen:
   *Neuroplastisity in patients with bipolar disorders.*
   Mentors: Ulrik Frederik Malt and Stein Andersson, Department of Neuropsychiatry and Psychosomatic Medicine, Espen Dietrichs, Department of Neurology, Ole Andreassen, Institute of Psychiatry, University of Oslo.

## PAEDIATRIC CARDIAC INTERVENTION

*Section manager Erik Thaulow, MD, PhD*

Rikshospitalet has been a prime mover in the Norwegian initiatives to decrease the invasiveness of repair of cardiac defects in children. It is well known that cardiac surgery in the young can contribute to psychological and developmental difficulties which are concern for families of such children. The uses of non-operative methods are desirable to replace surgery, especially those procedures that require heart lung machine and circulatory arrest. Using the combined operating suites and the multi-specialty approach of the Interventional Centre, repair of atrial septal defects has now become a non operative procedure for most Norwegian children. Similarly, some patients with VSD can also be treated in a similar fashion. The IVS is now embarking, as one of the first centers in the world on the non operative replacement of the pulmonic valve in a certain group of children. A comprehensive program of evaluation of short and long term outcomes in these patients as well as cost considerations for individuals and society are under planning. One PhD program is focusing on the patient experiences. The cooperation between the IVS and the Pediatric Clinic is the basis for further progress in interventional therapy. This relates both to practical arrangements, technical skills in the IVS staff and also broader support in developing these strategies.

## CARDIAC IMAGING

*Prof. Thor Edvardsen, MD, PhD*
*Prof. Halfdan Ihlen, MD, PhD*

The development of epicardial accelerometers and ultrasound probes for continuous monitoring of myocardial ischemia has resulted in 1 publication in a scientific journal during 2008 and several presentations at international conferences. The development of these devices has been in close collaboration with Dept of Cardiology. The idea behind the project is to improve per and post operative monitoring of myocardial function.

The introduction of 3T MRI at the Interventional Centre has augmented research efforts in cardiac imaging of structure and function of the heart. Several PhD students have ongoing projects that include cardiac MR.
One important trial will study patients with NSTEMI *(non ST-elevation myocardial infarct)* and another will study patients with stable angina pectoris.

**Ongoing PhD programs:**

1. Cand. Med. Eirik Pettersen:
   *Myocardial function studies.*
   Mentor: Kai Andersen, the Interventional Centre / Dept of Cardiology, RR-HF.

2. Cand med. Andreas Espinoza:
   *Miniaturized epicardial ultrasound probes for perioperative myocardial monitoring.*
   Mentors: Thor Edvardsen and Halfdan Ihlen, the Interventional Centre / Dept of Cardiology, RR-HF.

3. Cand. Med. Marit Kristine Smedsrud:
   *Myocardial viability in patients with stable angina pectoris.*
   Mentor: Thor Edvardsen, the Interventional Centre / Dept of Cardiology, RR-HF.

4. Cand. Med. Ckristian Eek:
   *Diagnostic and therapeutic stratification of patients with acute coronary syndrome (Echo-str-acs).*
   Mentors: Helge Skulstad and Thor Edvardsen, the Interventional Centre / Dept of Cardiology, RR-HF.

5. Cand. Med. Siv Hestenes:
   *Cardiomyopathy in sepsis.*
   Mentors: Thor Edvardsen, Erik Fosse and Erik W. Nilsen, the Interventional Centre / Dept of Cardiology, RR-HF.

## MEDICAL ROBOTICS APPLICATION AND CONTROL

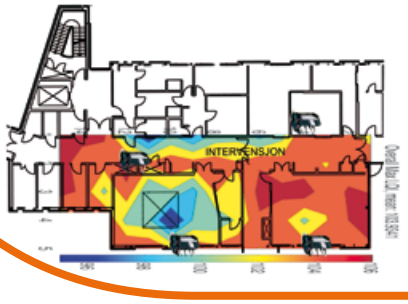
*Section manager Ole Jakob Elle, PhD*

Surgical robotics has been a research topic of the Interventional Centre since 1998. The Zeus Micro Joint telemanipulator has been used for animal studies performing coronary bypass-surgery and human trials for thoracoscopic IMA-takedown and sympatectomy.

The robotic group has developed a new head tracking control modality for steering the scope with a robotic scope holder using gyroscope sensors to track the head motion. This resulted in a PhD defended in 2004. In 2005 the research group was strengthened by a PhD fellow, Edvard Nærum, with the research topic of haptic and tactile feedback in remote surgery. Edvard Nærum has in 2008 been at a research stay at Seattle University, USA hosted by Professor Blake Hannaford. Two papers came out of this stay, and an important academic contact was established. Edvard Nærum is now working with his last study, and is planning to complete his PhD within 2009.

A post.doc in robotics, Jordi Cornella was employed in June 2006 to develop robotic control strategies with the use of a force sensor. The study is part of the ARIS*ER project *(EU's 6th framework)* and will provide the robotic system with both haptic feedback capabilities and autonomous function by sensing the force between the environment and the robot. Jordi Cornella finished his Post.doc in June 2008.
In 2007 a master project on haptic guidance was started. The purpose of the project is to help the surgeon follow an insertion path, e.g. needle insertion, and to provide no-go zones near critical structures based on segmented image data. The work with semi-autonomous robotic systems combining tele-manipulation with haptic feedback and automatic robotic tasks will be pursued, and the research group is involved in several applications within EU's 7th framework related to these topics.

The development of collision detection systems and visualization systems to help and guide the surgeon performing telemanipulated surgery was lead by the ARIS*ER PhD-student, Tangui Morvan. He made a demonstrator of this system in 2007, which was evaluated through a user study and published in 2008.




In 2006 a cross-disciplinary research collaboration between engineers and surgeons at the Interventional Centre and Department for Neurosurgery at Rikshospitalet University Hospital together with Neurosurgical Department and Department of Neuro Radiology at Ullevål University Hospital and Armstrong Healthcare Ltd., England. The dedicated person at Neurosurgical Department is Jon Ramm-Pettersen, MD *(neuro surgeon)*, at the Interventional Centre, Ole Jakob Elle, PhD *(engineer in robotics)* and at Armstrong Healthcare Ltd., Patrick Finlay. Hege Fredø at Ullevål University Hospital is dedicated to the project as a PhD student. The project is aimed at precise positioning of a tool within target points in the brain using image guidance and without the use of a stereo-tactic frame, by use of the neurosurgical PathFinder robot. This project is on hold due to software upgrade of the PathFinder robot as a result of our preliminary use of the system.

**The Robotic research group had one Post.doc. in 2008:**

1. Dr. Jordi Cornella (ARIS*ER – Experienced Researcher):
   *Integrating haptics with robotic systems and tele-manipulators.*
   Mentor: Ole Jakob Elle and Eigil Samset, the Interventional Centre, Rikshospitalet University Hospital.

**The Robotic research group had two PhD projects running in 2008:**

1. M.Sc. Edvard Nærum:
   *Haptic and tactile feedback in remote surgery.*
   Mentors: Ole Jakob Elle and Erik Fosse, the Interventional Centre, Rikshospitalet University Hospital.
2. Cand.Med. Hege Fredø:
   *Precise intracranial positioning – Robot controlled tool guidance in Neurosurgery.*
   Mentors: Iver A. Langmoen, Department of Neuro Radiology at Ullevål University Hospital and Ole Jakob Elle, the Interventional Centre, Rikshospitalet University Hospital.

**The research group had one Master student in 2008:**

1. Andreas Nygaard:
   *High-level control system for remotely controlled surgical robots – Haptic Guidance in robot assisted surgery.*
   Mentors: Øyvind Stavdal, NTNU, Ole Jakob Elle, and Jordi Cornella, the Interventional Centre, Rikshospitalet University Hospital.

## + WIRELESS SENSOR NETWORKS

*Professor Ilangko Balasingham, PhD*

The sensors, signals, and systems research group aims to facilitate deployment intelligent sensors and systems for different procedures in surgery, minimal invasive therapy and ambient point of care monitoring. The main focus area of research is in efficient design and development of novel sensors, power efficient real time signal processing algorithms, sensor data fusion, and wireless communication solutions for in vivo and ex vivo purposes. Some of our activities are on designing novel optical sensors to measure pH and medical radar based on ultra wide band impulse electromagnetic signals to measure blood pressure, blood flow and tissue /organ motions. Furthermore, novel signal processing algorithms to facilitate power efficient processing of digital data in sensors, which are popularly called as sensor nodes in wireless communications networks. The digital sensor data fusion and multi paramter analysis are also active areas of research. We are working to design reliable, power efficient and robust wireless body area sensor networks for in vivo *(implantable)* and ex vivo use.

We have a close collaboration with the Department of Electronics and Telecommunications at the Norwegian University of Science and Technology *(NTNU)* in Trondheim and several national and international research institutions and companies participate in different projects. Collaboration with the Nordic academic and industry has been through the Nordic project on Biomedical Wireless Sensor Network *(BWSN)*. A live demonstration of all sensors in a wireless system on an animal model was performed as a part of a final symposium of the project in February 2008. The BWSN project was awarded a second phase of funding for another 18 months from June 2008. The ULTRAsponder project *(EU FP7)* had its kickoff meeting in at EPFL in Switzerland in September 2008. The participants in this project from Norway are clinicians and engineers from Interventional Centre and the Department of Cardiology. Furthermore, the research group established collaboration with the Norwegian Defense Research Establishment *(FFI)* and the Nanoelectrnonics group at the Department of Informatics, University of Oslo. The consortium including NTNU submitted a STORIKT-project proposal on Medical Sensing, Localization, and Communication using Ultra Wideband Technology *(MELODY)* to the

VERDIKT program at the Research Council of Norway, which was selected for funding for 7 years *(4+3)* in March 2008, where the project had its kickoff meeting in September 2008. The kickoff meeting was attended by Mr. Arvid Hallén, CEO and several Head of Departments of Research Council of Norway, Mr. Morten Reymert, CEO of Rikshospitalet, Deans and Head of Departments from NTNU and University of Oslo, and Research Director of FFI. There were also representatives from industry.

There is also an effort to establish a test bed for designing, developing and testing new technologies in sensors and wireless systems at the Interventional Centre in collaboration with SINTEF and industry. A pilot study on establishing a test bed is underway.

A resource network group on Wireless Healthcare *(Trådløs pasient)* has been established funded, in part, by the VERDIKT program at the Research Council of Norway, Oslo Bio and MedCoast Scandinavia. The aim of the group is to define roadmap and R&D strategy to facilitate use of wireless and sensor technologies to provide personalized health and care in a ubiquitous manner. It also aims to bring together academia and industry, and also inform different ministries about similar initiatives in the Nordic and European arenas. The funding of this network has been extended for another two years from June 2008.

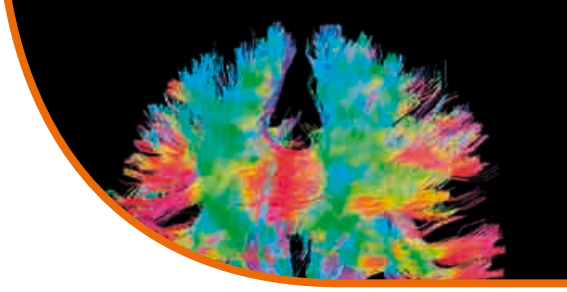
The research group, which is split between Oslo and Trondheim, has presently seven PhD fellows and four Post doctoral fellows employed through the projects. In addition to Vegard Nossum, Thomas H. Naustdal has joined the group as a Programmer and works part time. Dr. Sang-Seon Byun joined as a Postdoc fellow in the SAMPOS project for one year and is located at NTNU in Trondheim. Dr. Ali Khaleghi joined as a Postdoc fellow from January 2008 in the WISENET project for two years and is located at the Interventional Centre in Oslo. Dr. Djamel Djenouri joined as an ERCIM Postdoc fellow from October 2008 for one year and is located at NTNU in Trodheim. PhD student David Turgis from Katholieke Universiteit Leuven in Belgium went back to Belgium after spending 10 months at NTNU in Trondheim. Dr. Pål Anders Floor joined as a Postdoc fellow from December 2008 for two years and works in both MELODY and ULTRAsponder projects. Mr. Lars Erik Solberg has formally joined as a PhD student in the MELODY project and works in the area of UWB radars. Ms. Fatemeh Kazemeyni joined as PhD student in November 2008 and works in the CONNECT project. Two researchers from SINTEF in Trondheim and Norwegian Computing Centre in Oslo are working, in part, in the SAMPOS and WISENET projects.

**In 2008 this group had 7 PhD programs:**

1. MSc. Xuedong Liang:
   *Modelling tools for cross layer optimization in sensor networks.*
   Mentors: Ilangko Balasingham, the Interventional Centre, RHF, Olaf Owe and Einar Broch Johansen, University of Oslo.

2. MSc. Stig Støa:
   *Ultra wide band impulse radio.*
   Mentor: Ilangko Balasingham, the Interventional Centre, RHF.

3. MSc Hessam Moussavinik:
   *Super robust short range wireless sensor network.*
   Mentors: Ilangko Balasingham, the Interventional Centre, RHF, Geir Øien and Tor Ramstad. Norwegian University of Science & Technology, and Niels Aakvaag, Multihop Com AS.



4. MSc Pham Minh Long:
   *Distributed signal processing for power efficiency.*
   Mentors: Tor Ramstad, Norwegian University of Science & Technology and Ilangko Balasingham, the Interventional Centre, RHF.

5. MSc. Mariam Kaynia:
   *Adaptive spectrum allocation in wireless sensor network.*
   Mentors: Geir Øien and Tor Ramstad.
   Norwegian University of Science & Technology and Ilangko Balasingham, the Interventional Centre, RHF.

6. MSc. Fatemeh Kazemeyni:
   *Modelling tools and optimization of wireless sensor network.*
   Mentors: Ilangko Balasingham, the Interventional Centre, RHF, Olaf Owe and Einar Broch Johansen, University of Oslo.

7. MSc. Lars Erik Solberg:
   *UWB radars for medical applications.*
   Mentors: Ilangko Balasingham and Erik Fosse, the Interventional Centre, RHF, and Svein-Erik Hamran, Defence Research Establishment.

**In 2008 the group had four Postdocs:**

1. Dr. Djamel Djenouri:
   *Multi-objective QoS optimization in wireless sensor networks.*
   Mentor: Ilangko Balasingham, the Interventional Centre, RHF and Norwegian University of Science & Technology.

2. Dr. Sang-Seon Byun:
   *Development of Cognitive wireless sensor networks.*
   Mentor: Ilangko Balasingham, the Interventional Centre, RHF and Norwegian University of Science & Technology.

3. Dr. Pål Anders Floor:
   *Signal processing for robust wireless communications.*
   Mentor: Ilangko Balasingham, the Interventional Centre, RHF and Tor Ramstad, Norwegian University of Science & Technology.

4. Dr. Ali Khaleghi:
   *Invivo and exvivo UWB applications.*
   Mentor: Ilangko Balasingham, the Interventional Centre, RHF and Norwegian University of Science & Technology.

## NEURO COGNITIVE IMAGING

*Associate Professor Tor Endestad*

In cooperation with the Center for Study of Human Cognition at UiO a group has been established to work with basic research related to cognitive functions.
A facility for presentation of visual and auditive information has been set up for the 3T MR environment allowing for functional MRI studies.
The group is engaged in the study of memory and cognitive control. In one of the programs studies of early visual memory are combined with attention to better understand the building block of the human memory system. In addition memory errors *(false memories)* and the relationship between executive functions and impulse control are studied. Both patients with focal brain injuries and psychological disturbances are included in the research.
Several projects with cooperation between the Center and RH *(FRONT, SOBER3, HIPPO)* were started in 2008 addressing frontal lobe damage, hormone influence on cognitive functions and localization of memory functions in preoperative planning.
In addition to basic research, the group participate in the development of functional MRI as part of pre-surgical planning and improvement of neuropsychological diagnostics.

**PhD Projects:**

1. *Plasticity in the human visual system.*
   PhD student: Markus Handal Sneve.
   Principal res: Tor Endestad, Svein Magnussen.

2. *DTI: effects of varying number of diffusion sensitizing directions, b-value and NEX on diffusion metrics and tractography.*
   Phd Student: Lars Tjelta Wesby.
   Principal res: Anders Fjell, Kristine Walhowd, Atle Bjørnerud.

3. *FRONT Frontal Lobe Injury and cognition.*
   PhD Students: Marianne Løvås, Ingrid Funderud.
   Prinsipal res: Tor Endestad, Anne Kristin Solbakk, Magnus Lindgren.

4. *Å se farger som ikke finnes, en kombinert ERP og fMRI studie.*
   PhD Student: Lars Tjelta Westlye.
   Prinsipal res: Tor Endestad, Anders Fjell, Bruno Laeng, Kristine Walhovd.

5. *Parametric BOLD activation in multiple object tracking: Prediction of individual differences in attentional performance.*
   Phd: Markus Sneve.

**PostDoc projects:**

1. *Facing Doors.*
   Post Doc: Maria Korsnes.
2. *Memory, genetics & brain imaging.*
   Post Doc: Johanna Lind.
3. *Parametric BOLD activation in multiple object tracking: Prediction of individual differences in attentional performance.*
   Post Doc: Thomas Espeseth.

**Master students:**

1. *Can the brain make sense of nothing, fill in of the Blind spot.*
   Master student: Markus Sneve.
   Prinsipal res: Tor Endestad, Svein Magnussen.
2. *Memory and forward thinking.*
   Master student: Lasse Bang.
   Prinsipal res: Tor Endestad, Tim Brennen.
3. *Unconscious processing of emotions.*
   Master student: Ole Kristian Kristiansen, Marius Bøe Viken.
   Principal res: Tor Endestad, Bruno Laing.
4. *Cognitive control, mood, brain function and genetics in major depressive disorder and healthy people.*
   Master Student; Haakon Engen.
   Principal res: Tor Endestad, Nils Inge Landrø.
5. *SOBER Sex on brain European initiative.*
   Master Student: Nils Breivik.
   Principal res: Tor Endestad, Ira Haraldsen.
5. *Memory for trauma.*
   Master: Trine Elverum.
   Principal: Tor Endestad.

## MINIMAL INVASIVE VASCULAR SURGERY

*Section manager Kirsten Krohg-Sørensen, MD, PhD*

The development of minimally invasive vascular surgery has been executed by a multi-disciplinary group in the combined angio/surgery suite at the Centre.
The program has been focused on endovascular treatment of thoracic and abdominal aneurysms using endovascular stenting. The team led by Kirsten Krohg-Sørensen, has performed repair of thoracic and aortic stent grafts in a highly successful manner. The results have been documented in highly quoted international publications. One PhD program related to this project is planned. Contacts are being established to expand this program to more complex aortic pathology, including aortic arch pathology.

## IMAGE GUIDED NEUROSURGERY

*Section manager Torstein Meling MD, PhD*

For a number of years the Department of Neurosurgery has used the GE open magnet for MR-guided neurosurgery. There have been substantial developments in technological solutions, and many clinical studies in brain tumour resections, pituitary tumour surgery and brain biopsies have been performed. The open GE-magnet was replaced by a closed bore 3T MR in 2007, and we started to perform transphenoidal pure endoscopic pituitary surgery in this 3T OR room. The activity will be extended to include brain tumour surgery when all the hardware is installed.
In 2006 we started to perform vascular neurosurgical procedures guided by angiography in our combined angiography-operation suite. The angio-suite was refurbished and fitted with state-of-the-art intraoperative angiography equipment from Siemens in 2007 and again in 2008, allowing rotational angiography with 3D representation intraoperatively. This will facilitate our work on vascular neurosurgery guided by angiography.

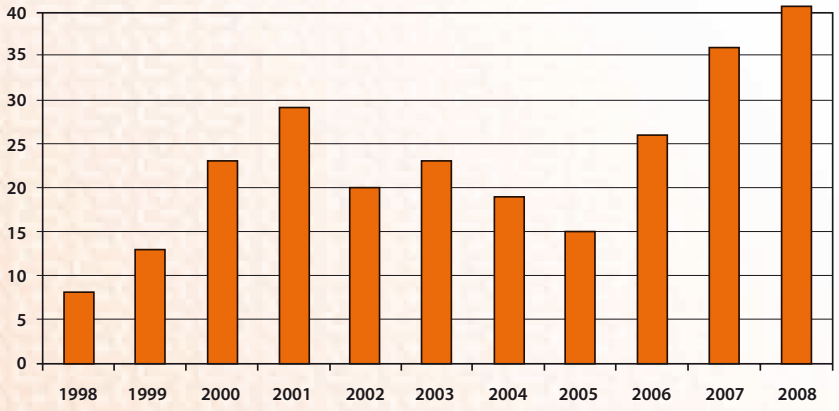
**Main projects in cooperation with the advanced imaging group are:**

- A study on whether 3T MRI characteristics can predict pituitary tumour consistency and hence suitability for transspehnoidal resection of macroadenomas.
- Establishing intraoperative tractography/DTI in the 3T MR.

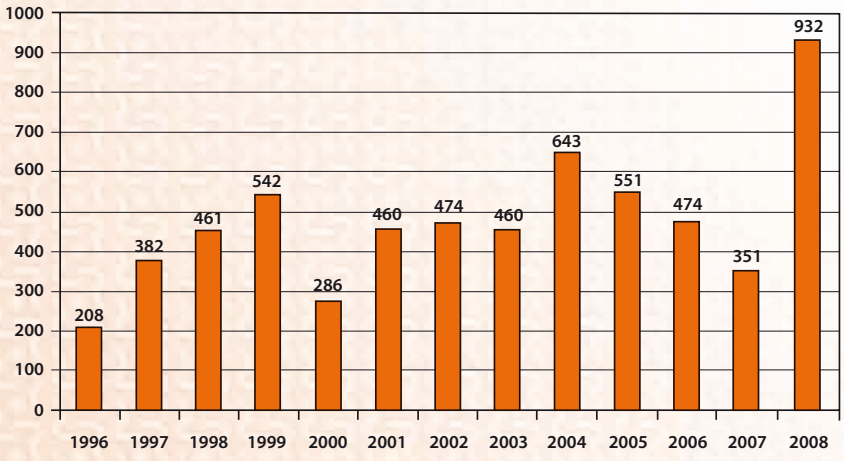
# Scientific Statistics

## THE INTERVENTIONAL CENTRE 2008

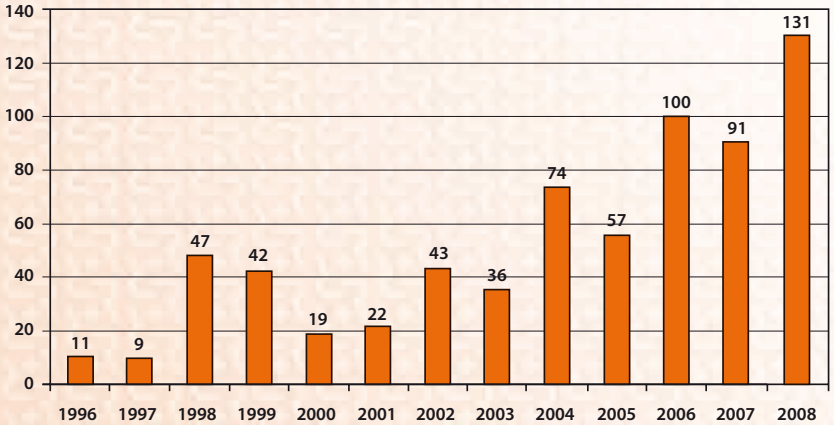
### PEER REVIEWED PAPERS




### HUMAN PROCEDURES




### TEST ANIMALS



# Budget and Expenditures

## THE INTERVENTIONAL CENTRE 2008

### INTERNAL HOSPITAL FUNDS ADMINISTERED BY THE INTERVENTIONAL CENTRE IN 2008

| | BUDGET | EXPENDITURE |
|---|---|---|
| Payroll expences | 13.394.000 | |
| Other operating expences | 6.274.000 | |
| **Sum internal finance** | **19.668.000** | **20.031.000** |

### EXTERNAL FUNDS ADMINISTERED BY THE INTERVENTIONAL CENTRE IN 2008

| SOURCE | INCOME | EXPENDITURE |
|---|---|---|
| Research Council of Norway | 5.195.000 | |
| Regional Health Authority | 457.000 | |
| European Commission | 2.098.919 | |
| University of Oslo | 120.000 | |
| National Heart and Lung Association | 560.000 | |
| Ministry of Foreign Affairs | 2.400.000 | |
| Research-, and pending expenditures | | 10.613.668 |
| **Balance** | **10.830.919** | 10.613.668 |

### DRG-POINTS GENERATED AT THE INTERVENTIONAL CENTRE *(80% refund)*

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| DRG | 731,7 | 885,5 | 837,1 | 791,6 | 1014,3 |
| NOK | 19.979 | 20.378 | 21.168 | 20.265 | 27.303 |

### DRG INCOME BY THE CLINICS IN 2008 *(80% refund)*

| CLINIC | DRG POINTS | VALUE NOK |
|---|---|---|
| Pediatric | 6,9 | 185.731 |
| Heart and Lung Clinic | 597,1 | 16.085.959 |
| Surgical Clinic | 336,0 | 9.044.314 |
| Medical Clinic | 7,4 | 199.190 |
| Neurosurgery Clinic | 59,7 | 1.606.981 |
| ENT | 7,0 | 188.423 |
| **Total** | **1014,1** | **27.310.598** |

# Patent Applications

## THE INTERVENTIONAL CENTRE 1998 – 2008

### ACTIVE PATENTS (GRANTED)

| PATENT NR. | TITLE | INVENTORS |
|---|---|---|
| EP 1063923 | Method and device for suturless anastomosis | Sumit Roy, Erik Fosse |
| WO 0169130 | Light system for use especially by operating theatre | Erik Fosse, Frode Lærum, Ole Jakob Elle |
| WO 0004386 | Device for PCO2 detection | Tor Inge Tønnessen, Peyman Mirtaheri |
| WO 9211823 | Filtering device for preventing embolism and/or distension of blood vessel walls | Frode Lærum |
| NO 20016385 | System for monitoring changes in movements of an organ, preferably a heart muscle | Erik Fosse, Ole Jakob Elle Martin Gulbrandsen |
| NO 20023605 | Method and device for connecting two tubular organs | Erik Fosse, Ole Jakob Elle, Sumit Roy |

### PENDING PATENTS

| PATENT | TITLE | INVENTORS |
|---|---|---|
| US PCT patent application: 2007 | Method and apparatus for visualization of a flexible body | Eigil Samset |
| US Patent: 20030114876 | Device for use by brain operations | Eigil Samset, Henrry Hirschberg, Åge Kristiansen |
| IPCS 8 class: AA61 1B603FI; USPC class: 600425 | Tumor grading from blood volume maps | Kyrre Emblem, Atle Bjørnerud |
| EP1632201 Implant | Implant | Bjørn Edwin, Erik Fosse |
| PCT/IB2007/050646 (also filed as EP1825839 "Implant" and WO2007/099500). 28/2 2006 | Implant and method for its manufacture | Bjørn Edwin, Erik Fosse |
| PCT/EP2008/060837 (also filed as EP2027835 "Implant" and WO2009/024568 "Percutaneous abdominal implant"). 21/8 2007 | Percutaneous abdominal implant | Bjørn Edwin, Erik Fosse |
| WO2009027522A1 | Automated monitoring of myocardial function by ultrasonic transducers positioned on the heart | Ole Jakob Elle, Erik Fosse, Halfdan Ihlen, Andreas Espinoza, Lars Hoff |
| WO2009004001A1 | Method and kit for sweat activity measurement | Ørjan Grøttem Martinsen, Sverre Jøran Grimnes, Erik Fosse |
| WO03061473A1 | Use of sensor and system for monitoring heart movements | Ole Jacob Elle, Erik Fosse, Martin G. Gulbrandsen |
| US20080281214A1 | Method for estimating cardiac pumping capacity | Ole Jakob Elle, Erik Fosse, Per Steinar Halvorsen |
| PCT/EP2009/055570. 8/5 2008 (and WO2009/024568). 21/8 2007 | Vessel segmentation in DCE MR imaging | Atle Bjørnerud, Kyrre Emblem |

# Academic Partners 2008

## NATIONAL ACADEMIC PARTNERS

**Norwegian Defense Research Establishment (FFI)**
*Prof. Torleiv Maseng*
*and Prof. Svein Erik Hamran*
MELODY project.

**St. Olavs Hospital Trondheim, NTNU**
*Assoc prof. Asta Håberg*
New statistical methods for improved characterization of gliomas.

**University Hospital Stavanger**
*Kathinka Kurz*
Characterization of breast tumors using MR mammography.

**Institute of psychology, UiO**
*Assoc. prof. Tor Endestad,*
*Prof. Svein Magnussen*
Cognitive function and fMRI.
*Prof. Anders Fjell*
MR morphometry and diffusion tensor imaging.

**Institute of Psychiatry, UiO**
*Prof. Ole Andreassen*
Neuroplastisity in patients with bipolar disorders.

**Centre for Micro technology, Vestfold University College**
*Assoc. Prof. Hans Jørgen Alker*
Cooperation on the project "Micro-heart". Based on a patent idea by the Interventional Centre an implantable micro sensor is being developed. The sensor will monitor changes in heart movement caused by ischemia. The project is financed by the Norwegian Research Council and includes several research fellows at the University College of Vestfold.

**Centre of Mathematics for Applications, University of Oslo**
*Prof. Knut Mørken*
The Interventional Centre and the Centre of Mathematics for Applications in cooperation tutored a PhD degree which was defended by Martin Reymers. The PhD was part of research cooperation about fundamental mathematical methods for use in image-guided treatment. Together with the Simula Centre, the Interventional Centre and CMA are applying for the STORFORSK project "Mathematical methods supporting minimally invasive therapy in medicine".

**Department of Computer and Information Science, Norwegian University of Science and Technology (NTNU), Trondheim**
*Bård Kjos, Prof. Richard Blake,*
*Prof. Hery Ramampiaro*
Image processing, data graphics, medical journal indexing and search engines. MSc student supervision.

**Department of Electronics and Telecommunications, Norwegian University of Science and Technology (NTNU), Trondheim**
*Prof. Ilangko Balasingham,*
*Prof. Tor Ramstad, Prof. Andrew Perkis,*
*Prof. Geir Øien*
Signal processing algorithms, wireless sensor network, multimedia patient record systems. Supervision of several MSc and PhD students.

**Department of Energy- and Processing Technique, Norwegian University of Science and Technology (NTNU), Trondheim**
*Prof. em. Magne Lamvik*
Thermodynamics, cryo ablation of the liver.

**Department of Engineering Cybernetics, Norwegian University of Science and Technology (NTNU), Trondheim**
*Prof. Olav Egeland and Prof. Bjørn Angelsen*
Robotic technique and ultrasound.

**Department of Informatics (IFI), Faculty of mathematics and national sciences, University of Oslo**
*Prof. Knut Mørken, Prof. Olaf Owe*
The Interventional Centre cooperated closely with IFI. The project consists mainly of supervision of master degree students, *(in 2006: 1 student)*.

The head of the technology section at the Interventional Centre is employed as assistant professor at IFI.
***Group for Precise modeling and Analysis.***
The collaboration between the Precise Modeling and Analysis group and the Interventional Centre has resulted in an EU FP6 IST project and a project funded by the Norwegian Research Council on modeling tools for wireless biomedical sensor networks. Xuedong Liang was hired as a PhD fellow in the EU project for three years whereas another PhD fellow will be hired soon in the CONNECT project, which is funded by the Norwegian Research Council.

**Department of Neuro Radiology, Ullevål University Hospital**
*Prof Per Nakstad MD*
Development of methods for precise intracranial positioning using Robot controlled tool guidance in Neurosurgery.

**Department of Neurosurgery, Ullevål University Hospital**
*Prof. Iver Langmoen*
Development of methods for precise intracranial positioning using Robot controlled tool guidance in Neurosurgery.

**Institute of Physics, Faculty of mathematics and natural sciences. University of Oslo**
*Prof. Sverre Grimnes, prof. Ørjan Martinsen*
Biolelectrical properties of human tissue
Development of a skin moisture sensor.
Two PhD programs.

**Dept of Radiology, The Norwegian Cancer Hospital**
*Prof. Arne Skretting*
Development of a radioactive gel for treatment of bowel tumours.

**The School of Pharmacy, Faculty of mathematics and natural sciences. University of Oslo**
*Prof. Jan Karlsen*
Development of a radioactive gel for treatment of bowel tumours.

## INTERNATIONAL ACADEMIC PARTNERS

**Sahlgrenska University Hospital, The ColoRectal Unit**
*Contact person: Prof. Leif Hultén MD PhD*

**Gøteborgs Universitet, Instutition för kliniske vetenskaper**
*Contact person:*
*Prof. Peter Thomsen MD PhD*

**University of British Columbia, Vancouver, Canada**
*Contact person: Prof. Victor Leung*

**Uppsala University, Sweden**
*Contact person: Prof. Anders Rydberg*
MELODY project.

**Royal Institute of Technology, Sweden**
*Contact person: Prof. Mikael Skoglund*
MELODY project.

**National Institute of ICT, Japan**
*Contact person: Prof. Huan-Bang Li*
MELODY project.

**Linköping University, Sweden**
*Contact person: Prof. Erik G Larsson*
MELODY project.

**SORIN Group, France**
*Contact person: Dr. Renzo Dal Molin*
MELODY project.

**University of California Santa Barbara, USA**
*Contact person: Prof. Ken Rose*
MELODY project.

**EURECOM, France**
*Contact person: Prof. Raymond Knopp*
MELODY project.

**Univeristy of California San Diego**
*Contact person: Prof. Anders Dale*
Novel methods for quantification of tumor growth.

**University of Heidelberg**
*Contact person: Frank Zoellner*
Novel statistical methods for predictive modeling of tumor grade.

**Uppsala Universitetet**
*Contact person: Prof Håkan Ahlström*
MR based Quantitative perfusion analysis.

**I.M. Setchenov Moscow Medical Academy Moscow, Russia**
The co-operation involved exchange of medical students in addition to an extensive collaboration in the development of laparoscopic surgery with guest instructors from Norway and several seminars in Moscow.

**Department of Anaesthesiology, Massachusetts Medical Center, Boston, USA**
*Contact person: Prof. Babs Soller*
Collaboration in the SAMPOS project on optical pH-sensor.

**Department of Cardiovascular Surgery, University Medical Center Ljubljana, Slovenia**
**(Academic partner – ARIS*ER)**
*Contact person: Borut Gersak*
They are a clinical academic partner in the ARIS*ER project and responsible for the development of new methods in minimally invasive Mitral Valve Repair and Replacement.

**Department of Radiology, Brigham and Women's Hospital, Harward University, Boston**
*Contact person: Prof. Ferenc Jolesz*
BWH has been a leading hospital in introducing MR guided treatment as a research field and has made new methods for treatment of patients. The cooperation consists of exchange of research personnel. An application named "Development of novel applications for high-field MRI-guided therapies" was granted by the Norwegian

research council (NRC) in 2004 for three years financing of the project.

**Graz University of Technology, Austria (Academic partner – ARIS*ER)**
*Contact person: Dieter Schmalstieg*
Their responsibility within the project is new methods for Augmented Reality Visualization.

**IFC-CNR, Institute of Clinical Physiology, Biomedical Engineering Science and Technology Division, Lecce, Italy (Academic partner – ARIS*ER)**
*Contact person: Sergio Casciaro*
Their responsibility is new methods for medical image segmentation.

**School of Computer and Communication Sciences, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland & Department of Electrical Engineering, University of California, Berkeley, USA**
*Contact person: Prof. Martin Vetterli*
Collaboration in the SAMPOS and WISENET projects on signal processing in sensor nodes.

**School of Electrical Engineering, Royal Institute of Technology (KTH), Stockholm, Sweden**
*Contact person: Prof. Erik Larsson*
Collaboration in the SAMPOS project on wireless sensor networks.

**Technical University of Delft, The Netherlands (Academic partner – ARIS*ER)**
*Contact person: Adinda Freudenthal*
Their responsibility is to link clinical needs into useful system features by using user-centred design methods.

**The Katholieke Universiteit Leuven, Belgium (Academic partner – ARIS*ER)**
*Contact person: Jos Vander Sloten*
Their responsibility is haptic/tactile feedback related to telemanipulators and robotics to crosslink image information with robotic control.

**University Hospital of Tuzla, Dept. Cardiac Surgery, Bosnia**
*Contact persons: Prof. Emir Kabil, Dr. Jacob Bergsland*
Since 1998 The Interventional Centre (IVS) has been active in building medical expertise in Bosnia. The Cardiovascular Clinic in Tuzla which was started with assistance from USA soon developed a close relationship with the Centre and Department of Thoracic Surgery at Rikshospitalet. The cooperative program has continued in 2008. The program has supported by grants from the Royal Norwegian Foreign Department.
In 2008 the activity focused on further education of medical personnel and the development of academic expertise. A simulator training program was initiated in cooperation with Sim Surgery an Interventional Center spin-off. Research initiatives have included preparation for two important research projects to be conducted as collaborative programs between Rikshospitalet and Tuzla: A cross-sectional study to look at the incidence of cardiovascular risk factors in a rural and urban population in Bosnia, and a randomized study evaluating the effect of platelet active drugs in coronary artery bypass patients. ICT initiatives have been continued to improve the access to clinical and research data for the hospitals in Bosnia. A new application for funds to improve neurosurgery, radiology and the treatment of acute myocardial infarction will be focused together with e-health and reform.

# Commercial Partners

**Cancer Cure as**
*Gunnar Myhr CEO*
Collaboration for development of a system for targeted drug delivery under MR guidance.
Other partners:
Institute for Cancer research.

**Hospitality AS, Norway**
*Contact person:*
*Mr. Flemming Bo Hegerstrøm*
MELODY project.

**Lifecare AS, Norway**
*Contact person:*
*Dr. Erik Johannessen*
MELODY project.

**IBM Healthcare, Norway**
*Contact person:*
*Mr. Jan Fredrik Sagdahl and Frode Tveit*
MELODY project.

**NordicNeuroLab AS, Bergen**
Development of comprehensive software package for advanced functional image analysis.

**Sectra AB, Sweden**
Integration of in-house developed software into hospital PACS.

**CorTechs Labs, San Diego**
Novel methods for quantification of tumor growth.

**ABB Corporate Research, Oslo**
*Contact person: Dagfin Brodtkorb*
Collaboration in the SAMPOS and WISENET projects on robust wireless communications.

**Acreo AB, Göteborg, Sweden**
*Contact person: Dr. Michael Salter*
Collaboration in the BWSN project.

**ADIGO, Oppegård**
*Contact person: Øyvind Overskeid*
Collaboration on devices for laparoscopic surgery.

**Alertis Medical AS**
*Contact person: CEO Martin Krekling*
Development of a pCO2 sensor.
Five PhD programs.

**Ericsson AB, Göteborg, Sweden**
*Contact person: Dr. Arne Alping and Dr. Thomas Lewin*
Collaboration in the BWSN project.

**GE Healthcare**
*Contact person: Audun Thornes*
Development of MR contrast media.
The project involves the Clinic for intervention and imaging, the Institute for cancer research, the department for comparative medicine and the Interventional Centre.

**GE Vingmed-Sound**
*Contact person: Gunnar Hansen*
Development of ultra sound equipment for cardiology.

**Healthy Pointers**
*Contact person: Stian Aldrin*
Pointing device for laparoscopic surgery.

**Imego AB, Göteborg, Sweden**
*Contact person: Dr. Peter Bjökholm*
Collaboration in the BWSN project.

**Kongsberg SIM**
**(Industrial partner – ARIS*ER)**
*Contact person: Øyvind Rideng*
Systems in Motion provides the project with a 3Dgraphics library. Their responsibility in the project is parallelized 3D rendering.

**Memscap AS, Horten**
*Contact person: Andre Larsen*
Collaboration in the BWSN and WIRE-MED projects on MEMS based pressure sensors.

**Millicore AB, Norrköping, Sweden**
*Contact person: Mikael Löfgren*
Collaboration in the BWSN project.

**Multihopp Communications, Oslo**
*Contact person: Niels Aakvaag*
Collaboration in the WISENET project on robust wireless communications.

**Norwegian Computing Center, Oslo**
*Contact person: Dr. Wolfgang Leister*
Collaboration in the SAMPOS project on security and authentication platform in wireless sensor systems.

**Novelda AS, Oslo**
*Contact person: Eirik Næss-Ulseth*
Collaboration in the BWSN, WIREMED, and Medical Radar projects on ultra wide band impulse radio platform for medical communications and remote sensor.

**Novosense AB, Lund, Sweden**
*Contact person: Karl-Johan Ohman*
Collaboration in the BWSN project.

**OstomyCure**
*Contact person: Martin Johansson*
Development of medical implants.

**Phillips Medical Systems**
*Contact person: Jørn Kværnes*
Development of systems for MR-guided interventions and surgery.

**Prosurgics Ltd, High Wycombe, United Kingdom**
*Contact person: Patrick Finley*
The collaboration is concentrated around the neurosurgical robot PathFinder from Prosurgics Ltd. The aim is to precisely position a tool within target points in the brain using image guidance and without the use of a stereotactic frame.

**Siemens Medical Imaging, Erlangen, Germany**
*Contact person: Lutz Bluhm*
Integration of the Zeego angiographic system in the OR.

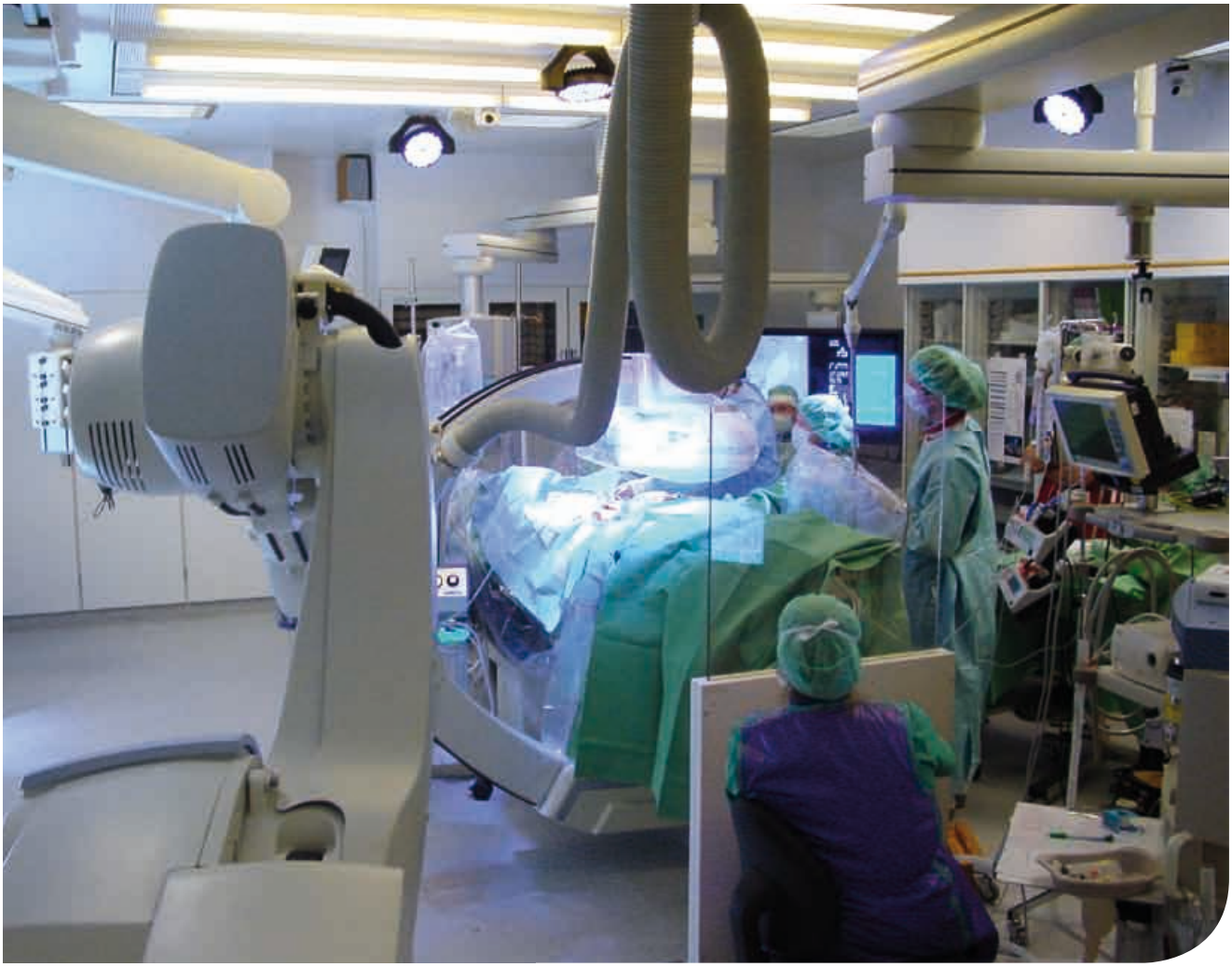
**Siemens Magnet Technologies (Industrial partner – ARIS*ER)**
*Contact person: Robert McLaughlin*
They are responsible for image registration to ensure optimal correlation between the different medical image modalities like CT, MR and ultrasound.

**SimSurgery AS**
*Contact person: M.D. Vidar Sørhus*
SimSurgery AS is pioneering the development of advanced real-time 3D simulations for surgical procedures. SimSurgery AS started due to clinical needs specified by the Interventional Centre. After a feasibility study SimSurgery was established *(Sept. 1999)* with researchers from the Interventional Centre and SINTEF. There is an ongoing collaboration in development and quality assessment of the simulators.

**SINTEF ICT, Oslo**
*Contact person: Dag Ausen*
Collaboration in the WIREMED project on MEMS technology for implantable pressure sensors.

**SINTEF ICT, Trondheim**
*Contact person: Knut Grythe*
Collaboration in the SAMPOS project on QoS metric in wireless sensor network.

**VTT Information Technology, Helsinki, Finland**
*Contact person: Marku Jennu*
Collaboration in the BWSN project.

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5. Lærum F, Borchgrevink HM, Fosse E, Faye-Lund P.
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9. Naesgaard JM, Edwin B, Reiertsen O, Trondsen E, Faerden AE, Rosseland A.
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10. Samset E, Hirschberg H.
***Neuronavigation in intra-operative MRI.***
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***Intraoperative image directed dye marking of tumour margins.***
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14. Djupesland PG, Qian W, Furlott H, Røtnes JS, Cole P, Zamel N.
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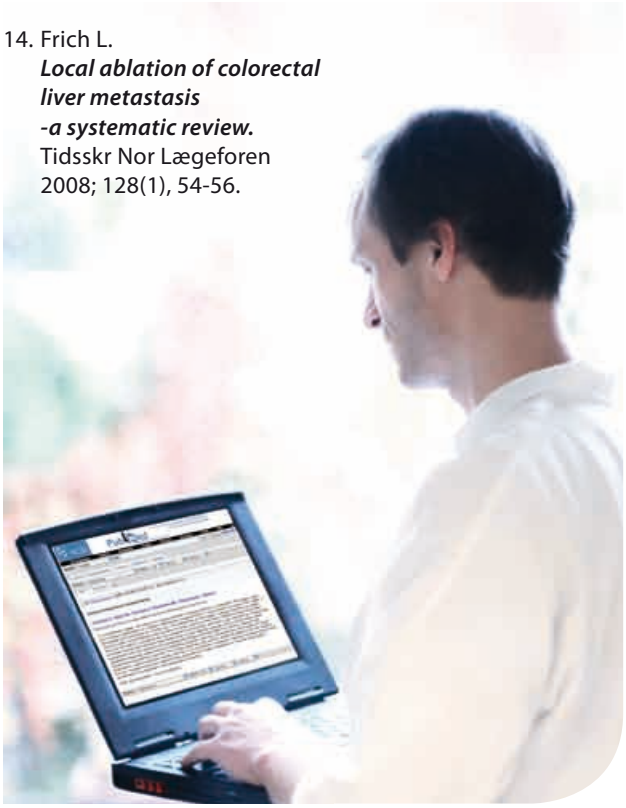

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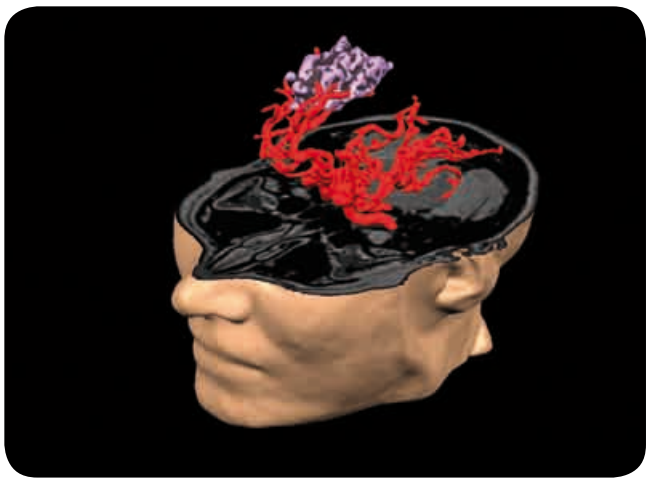

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