Annual report 2016
Operating Room of the Future
Summary

The Operating Room of the Future (FOR) is a research infrastructure facilitating research and development within the surgical disciplines. The main focus is minimally invasive surgery. FOR is taking part in several research projects and several of them, but not all, are led by FOR. In the present report we have included some projects where FOR and its staff has represented a prerequisite for the completion of the project.

The Operating Room of the Future is a collaboration between St. Olav’s Hospital HF, University Hospital of Trondheim and the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. FOR is an interdisciplinary arena for clinical research and for the development of medical technology.

FOR is set up to promote a close collaboration between clinicians, technologists, researchers and industrial partners who play a role in the development and innovation of the health care sector. This collaboration is reflected in the present annual report.

The principal activity at FOR is research to provide safer and better treatment, more efficient logistics and flexible architecture in the construction of new operating rooms. FOR has also become a center of competence for the construction of operating rooms outside St. Olav’s Hospital.

FOR has now its basis in six operating rooms at the new St. Olav’s Hospital; one at each of the operating departments. The operating rooms are designed for development, testing and implementation of new technology. Here, prototypes can be developed and tested in safe and controlled environments.

The FOR concept demonstrates synergy effects in letting representatives from various disciplines and medical specialists use equipment, areas and competence together.

Minimally invasive image guided treatment is an important research field at FOR. The scientific advisory board at FOR is going through all projects to ensure that a good quality of the research is obtained. FOR has excellent facilities for research projects based on a multidisciplinary approach. Investigations are performed by PhD-candidates, as well as students on a bachelor and master level. In addition FOR is running its own innovation-and research projects.

FOR-NorMIT – Norwegian center for Minimally Invasive image guided Therapy and medical Technologies-is a collaboration between FOR and the Intervention Center at Oslo University Hospital (OUS). This infrastructure will contribute to improved technological and clinical research, which again will improve the patient treatment nationally as well as internationally. FOR is also taking part in research on work flow, visualisation and communication technology. The operating rooms and the research tools, which are available through NorMIT, Trondheim are actually modern research laboratories developing, testing and implementing new technology for new treatment modalities.

The tasks of the University Hospital is defined in the specialist health care act and include treatment of patients, teaching of patients and their relatives as well as teaching of health care personnel. Trondheim has a particular responsibility for research within the field of medical technology.

Lecturing of the application of electro-medical equipment has become an important task for FOR. On behalf of the clinics FOR is organising courses and certification in the use of electro medical equipment. These courses are compulsory for all doctors in the FOR clinics and they are arranged via the so called “Portal of competence” at St.Olavs Hospital. Patient safety is an important part of the FOR activity and so is the work to reduce the incidence of hospital infections.

We want to thank all our collaborators for their contributions at FOR and NorMIT.

And we hope that you will enjoy our annual report of 2016!
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St. Olav's Hospital HF, University Hospital of Trondheim, is integrated with NTNU and owned by Central-Norway Regional Health Authority RH. Treatment of patients, teaching of patients and their relatives as well as research and teaching of health care personnel, are the main tasks of the hospital as defined in the specialist health care the hospital covers psychiatry as well as somatic health care.

St.Olavs Hospital is running centers several places in Sør-Trøndelag county. In addition to the institutions in the center of Trondheim, hospital activity is taking place at:

- Orkdal Hospital
- Røros Hospital, Røros
- Departments of psychiatry at Østmarka and Brøset in Trondheim
- Three district centers for psychiatry; Orkdal DPS in Orkdal, Nidaros DPS and Tiller DPS in Trondheim
- Several psychiatry outpatient clinics for children and young patients in Sør-Trøndelag
- Department of psychiatry for children and youth at Lian
- Habilitation unit for adult patients at Brøset, Trondheim
- Several outpatient clinics for psychiatry in Sør-Trøndelag

St.Olavs Hospital is the university clinic of Central Norway for a population of 720,931 inhabitants, and local hospital for a population of 317,282 per 01.01.17.

Through excellent cooperation with the local authorities and the primary health care, we aim at optimal patient care in the hospital as well as the primary health care. Excellent cooperation with the primary health care has led to the establishment of district medical centers at Fosen and Værnes. In the Trondheim region such centers have been established at Øya health center and at Søbstad health center.

Our core values are integrity, equality, respect and co-determination, forming the background for our clinical activity and our students, colleagues and collaborators. St. Olav's Hospital is integrated with the Norwegian University of Science and Technology, NTNU, and students, teachers and scientists are representing natural parts of the hospitals' activity. Within teaching and research we are collaborating closely with several other institutions in central Norway.

In addition to the scientific activity, The University Hospital is responsible for the training of medical students and other health care professions. It is also responsible for the training of medical specialists in central Norway.

In 2016 we had:

- 10,532 employees
- 43 operating rooms at St.Olavs Hospital, Trondheim. In addition 5 operating rooms at Orkdal Hospital and 2 operating rooms at Røros hospital
- A total of 467,990 somatic outpatient consultations
- 737 beds (somatic)
FOR – a brand for R&D

R&D is an abbreviation, an acronym for Research and Development; the activity going on in a development department based on systematic work and research. For the majority, perhaps R&D is associated with industrial activity rather than hospitals. However hospitals have become large and complex organisations and both diagnostic work and treatment is advanced and in a rapid progress. There is an increasing need for more innovative solutions for the best of our patients. FOR has become established as an innovative research infrastructure, a unit for R&D, for St.Olavs Hospital, for the faculty of medicine and health sciences at NTNU, as well as for the whole health region. This has not come by itself. An initial good idea followed by hard work over time by all collaborators has been a prerequisite, for cooperating partners, scientists, clinicians, industry and international contacts to recognise FOR, and to realize what FOR is capable of delivering. FOR has become a brand for quality and commitment. Therefore, at St.Olavs Hospital, we do not have a separate department of innovation or R&D, since FOR is covering these activities.

Petter Aadahl
Director of research and development
St.Olavs Hospital

Photo: St.Olavs Hospital
Björn I. Gustafsson, Dean of the Faculty of Medicine and Health Sciences, NTNU

The Operating Rooms of the Future (FOR) is an important infrastructure and contributor for interdisciplinary approach to medical problems and challenges. FOR is a collaboration between St.Olavs hospital and NTNU based on operating rooms which are constructed for the testing, development and implementation of new technology and new treatment modalities. This infrastructure is important for a close cooperation between the health care sector, the university and the industry.

The Health Authorities of Central Norway will, according to the assignment document of The Ministry of Health and Care, strengthen the cooperation on innovation between the specialist health care and the industry. This is in accordance with the governments’ action plan for follow-up of the national strategy “Health and Care 21” where the aim is a targeted effort for the 21. Century within the effort chain from research to innovation and commercialization.

FOR has an excellent cooperation with the various technology groups at NTNU, SINTEF and The Intervention Center at The National Hospital and with national as well as international industry. This is forming the basis for clinical research, development of medical technology and teaching. At the same time it gives us better treatment modalities for the benefit of our patients.

The industry also see advantages in the cooperation within research and development with NTNU. A recent report from the Danish “Damvd Analytics” concludes that companies having R&D cooperation with NTNU are significantly more successful than other industrial companies in the society. This indicates the important role which NTNU is playing for Norwegian industry.

Still, there is a great potential for more innovation within the health care system, especially regarding medical technology, logistics, patient flow and communication. More engagement is needed to get a sustainable health care service. What is your contribution? It is important to stimulate employees, students and collaborators for scientific work. Please let us hear from you whether you have suggestions to obtain more innovation within the health care sector. FOR will continue to have a key role and contribute to innovation in the health care sector, and thereby the creation of value for the individual as well as for the society as a whole.
Organization of the Operating Room of the Future

Overview of the FOR research infrastructure
Staff

Hans Olav Myhre
Emeritus Professor
of surgery

Jan Gunnar Skogås
Biomedical Engineer
Managing director

Ivar Rossvoll
Assistant professor
Scientific adviser

Ronald Mårvik
Assistant professor
Consultant surgeon
Department of
Gastrointestinal surgery

Marianne Haugvold
Adviser R&D
Cand. Scient.

Liv-Inger Stenstad
R&D coordinator
Radiographer
MSc, Clinical research

Geir Andre Pedersen
Project coordinator
NorMIT

Gabriel Kiss
R&D coordinator
Engineer / Researcher
NorMIT coordinator

Frode Manstad-Hulaas
Assistant professor
Intervention radiologist

Janne Hofstad
Surgical nurse

Photo: St.Olavs Hospital
Scientific advisory board

An important task for FOR is to improve the quality and quantity of clinical research. Therefore the scientific advisory board is going through all research protocols, giving advice to those who are doing projects under the direction of FOR. FOR has special guidelines for projects, including the tasks of the scientific advisory board as well as a description how to make research protocols (Professor Per Farup). These documents are forming the basis for the collaboration between FOR and those who are conducting research projects there. In addition we are making separate agreements between FOR and the project leaders.

In 2016 altogether 12 bachelor degrees, 6 master degrees and 2 PhD degrees were finished in collaboration with FOR. FOR will also have several main subjects for medical students including research line students who want to spend more time doing scientific work.

The scientific advisory board has the following members:
- Assistant professor Ivar Rossvoll (leader)
- Emeritus professor Hans Olav Myhre
- Professor Per Farup
- Professor Olav Haraldseth
- Professor Ståle Nordgård
- Assistant professor Frode Manstad-Hulaas
- Assistant professor Knut Haakon Stensæth
- Research direktor Thomas Langø

Ivar Rossvoll
Photo: St. Olavs Hospital

Hans Olav Myhre
Photo: St. Olavs Hospital

Per G. Farup
Photo: Private

Olav Haraldseth
Photo: NTNU

Ståle Nordgård
Photo: NTNU

Frode Manstad-Hulaas
Photo: St. Olavs Hospital

Knut Haakon Stensæth
Photo: Private

Thomas Langø
Photo: SINTEF
NorMIT is a national collaboration where the aim is to establish an infrastructure which will contribute to the improvement of technological and clinical research. It will also contribute to the building of competence and innovation and thereby lead to improved patient safety. Although the main focus area for the infrastructure is minimally invasive image-guided therapy, the research will also include topics like logistics, work flow, communication, organisation and transmission of high-quality images.

The operating rooms included in NorMIT are actually modern research laboratories for developing, testing and application of new technology, new treatment modalities and new pharmacological agents. The cooperation and different profiles of the centres will form them into one national infrastructure for image guided treatment and technology. The research units in Trondheim and Oslo represent two of the strongest groups in Norway within their fields, and they play an important role in the development of methods and technology also from an international point of view.

The Intervention Center at Oslo University Hospital and Operating Rooms of the Future are planning to make NorMIT one common infrastructure for research and innovation with two nodes; one in Trondheim and one in Oslo. This infrastructure will strengthen research significantly in several areas with great strategic significance for Norway: medical technology, ICT, nanotechnology, translation research and health innovation.

Activity in 2016
In 2016 most of the planned NorMIT infrastructure in Trondheim is now ready. The final investments will be done in 2017. The equipment can be booked via normit.no, where the use is entered into the log and where fee for use has been introduced. The booking system at normit.no has made it significantly easier for research groups to book time at the infrastructure.

The navigation platform NorMIT Nav
In the sub-project NorMIT, IGT, the navigation platform is separated in two parts; NorMIT-Plan (A planning module with a 3D model based on preoperative imaging data indicating the planned resection) - and NorMIT-Nav; which is a navigation module where a 3D model from NorMIT plan is included-and where spatial information about the positioning of the instruments is shown in the model during the operation. Both parts of this project involve the manipulation of intraoperative data and indicate how these are updating the 3D model in the most effective way. The navigation module will be an integrated part of the the NorMIT infrastructure, and will be ready at the new hybrid operating room at the Intervention Center during the autumn 2017.

New project leader in NorMIT
Jan Gunnar Skogås was taking over as project leader at NorMIT from January first 2017. He is replacing Petter Aadahl who has been leader since the start of NorMIT in 2014.

An important cooperating partner is “Center of Competence for ultrasound and image guided treatment” which is a national center of competence founded by the ministry of health and care services. NorMIT has numerous potential users and aims at an extensive cooperation between academic units, the industry and clinical center both from a national as well as an international point of view.

Please visit normit.no for more information!
State visit to Finland

The operating Room of the Future had the honor of joining the delegation of Their Majesties King Harald V and Queen Sonja on their state visit to Finland, 6-7 September 2016. During the two days visit we visited Helsinki and Oulu, discussions related to precision medicine and citizen centered healthcare were very interesting and relevant for the Operating Room of the Future.

During the visit to the Helsinki University Hospital (Biomedicum) areas for potential collaboration between Finland and Norway have been identified. They include precision medicine, personalized treatments, mobile and digital healthcare solutions, big data or joint multicenter studies. Having similar health care systems makes data collection and sharing possible and joint research feasible.

The TestLab at Oulu University Hospital shares many similarities with FOR in providing an arena where clinicians, researchers and industry partners can meet and interact with the main goal being the improvement of patient care. Several interactive demos were presented: wireless tablet based ultrasound system (EyeLife), virtual reality system to aid the speech impaired (Peilivision), handheld retina scanners (Optomed), real-time localization and communication solutions for the hospital (9solutions).

Photo: Gabriel Kiss, FOR

The Annual Røros FOR seminar 2016

The annual FOR seminar was arranged at Røros January 28.-29 2016. About 60 participants from St.Olav Hospital, NTNU, SINTEF, IVS/OUS and from industrial partners met for inspiring days in this beautiful mountain area. Guest-lecturer Tor Henrik Krogstad, HUCON Global, had an exciting presentation with the title “The significance of focusing on human constrains in training and evaluation of procedures has never been more important. What is the experience form the aviation area?” This is a topic which is highly significant for the health care system. Other topics at the symposium were medical technology, innovation, new treatment modalities, infrastructure and research tools. To meet at another arena than during daily routine work promotes new ideas and strengthens the infrastructure.
Newsletters from FOR

In October 2014 the first newsletter from FOR was available. So far the newsletters have been a great success. Three-four newsletters are distributed annually. They are focusing on the activity at the FOR operating rooms and are including visits at FOR, meetings, courses and information about scientific projects. In each issue we try to focus particularly on one of our clinics. We think this is a useful way of informing about FOR and hope you will enjoy it.

If you would like to read the newsletters please visit this link: https://stolav.no/fag-og-forskning/kompetansetjenester-og-sentre/for

3 newsletters were published in 2016 - March, June and December.
Activity at The FOR operating Rooms

Surgical Clinic

There has been an increasing need to use the Operating Room of the Future in the Emergency center. The Cardiovascular surgeons have become increasingly more dependent on the Operating Room of the Future for stent grafting of aortic aneurysms, combined surgery and endovascular procedures and isolated endovascular treatment. These treatments as well as the TAVI activity is becoming consistently more complex, and the increased use of the Operating Room of the Future by the clinics is causing wear and tear on the equipment, and unfortunately, we have had several periods of repairs and downtime during the past year. The Operating Room of the Future might need a necessary upgrade and the hospital as a whole may need more treatment rooms with possibilities for utilizing intraoperative fluoroscopy.

The project which uses angiosimulator prior to the introduction of stent graft is still moving forward, and the operation team is now training the day before the procedure. I am pleased to see that the relatively expensive simulator is regularly used to make the operational interventions better.

The experimental activity is increasing, and it is performed by both model tests on navigation and aneurysm treatment, and animal experiment in the field of cardiovascular surgery and pulmonary medicine. Steerable catheters are now available for experimental treatment, and we believe that this will eventually simplify endovascular procedures.

There is an increasing focus on radiation exposure in relation to endovascular procedures, and here the Operating Room of the future has conducted several studies formed a basis on which the radiation exposure can be monitored continuously with electronic equipment. This is a good initiative for HMS, and another good example of how the work at FOR has important impact on daily routines.

Birger H. Endreseth
Head of Surgical Clinic
Photo: St. Olavs Hospital
### Operative activity FOR operating room AH-1F

**Department of Surgery 2016**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAVI</td>
<td>62</td>
</tr>
<tr>
<td>EVAR</td>
<td>94</td>
</tr>
<tr>
<td>Various vascular operations</td>
<td>33</td>
</tr>
<tr>
<td>Thoraco-abdominal stent-grafts w/ side branches</td>
<td>3</td>
</tr>
<tr>
<td>Combined procedures (open operation +PTA/stent)</td>
<td>38</td>
</tr>
<tr>
<td>PTA/stent</td>
<td>26</td>
</tr>
<tr>
<td>Various endovascular procedures (coiling etc.)</td>
<td>7</td>
</tr>
<tr>
<td>Removal of infected pacemaker wires</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>277</strong></td>
</tr>
<tr>
<td>Experimental surgery and other research</td>
<td>6</td>
</tr>
</tbody>
</table>

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**TAVI 2016**

62 patients (57 native stenosis and 5 degenerate surgical valves). Age 81 years (62-92) 56% women, 44% men. 55 femoral, 5 apical and 2 trans aortal procedures.
Thorako-laparoscopic technique of oesophagus resection. FOR-operating room at Gastro.
Photo: Liv-Inger Stenstad, FOR

<table>
<thead>
<tr>
<th>Operative activity, FOR operating room 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of surgery 2016</td>
<td></td>
</tr>
<tr>
<td>Upper gastro</td>
<td>97</td>
</tr>
<tr>
<td>Middle gastro</td>
<td>148</td>
</tr>
<tr>
<td>Lower gastro</td>
<td>281</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>526</strong></td>
</tr>
</tbody>
</table>
FOR activity in the Clinic for Medical Imaging

The Clinic for medical Imagine (KBD) has for many years contributed to the implementation of many studies and clinical treatments at FOR in AHL, as well as in 2016.

With the introduction of stent graft in aorta, intervention radiologists have a central role in their close interaction with the vascular surgeons. This is a good example of how modern medicine depends on a good interaction between different specialties to achieve good results for patients. In 2016, 69 stent grafts was inserted into the abdominal aorta, of which 8 were acute. In the thoracalorta 12 stent grafts were inserted, of which 4 were acute. In addition, 4 thoracoabdominal stent grafts were inserted, all as elective interventions. 7 of these interventions were performed on rtg. Lab 27 due to technical problems on in AH-1F. In addition, combined surgery with the vascular surgeons is carried out on the pelvis and the lower limbs. In 2016, 39 such interventions were carried out, combining the use of traditional open surgery with blocking / stenting of veins in the same vision. Doctors from KBD are also involved in planning TAVI procedures.

Of research projects, KBD personnel have also participated in the following projects:


Erik Nypan, medical student, finished in 2018.

Other FOR-related papers:

Amundsen, Tore; Sørhaug, Sveinung; Leira, Håkon Olav; Tyvold, Stig Sverre; Langø, Thomas; Hammer, Tommy Arild; Manstad-Hulaas, Frode; Mattsson, Erney. A new removable airway stent. *European Clinical Respiratory Journal* 2016; Volume 3. (1)

After an upgrade of the angiosimulator in 2016, a PhD is now under way. Work where radiologists and caregivers practice the procedure on the patient’s own CT images the day before surgery. In this study, 30 patients are scheduled to do both quantitative and qualitative analyzes. The operators also fill out the questionnaire for each patient for a subjective description of the use of the simulator in the preoperative planning. It will be exciting to see how preoperative simulation will affect our working methodology in the future.

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<table>
<thead>
<tr>
<th>Activity that the Clinic for Medical Imaging has participated in at the FOR operating room at AHL 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stent grafts in the abdominal aorta</td>
</tr>
<tr>
<td>Stent grafts in the thoracic aorta</td>
</tr>
<tr>
<td>Thoraco-abdominal stent-grafts w/ side branches</td>
</tr>
<tr>
<td>Combined intervention in the pelvis and lower extremities</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
FOR activity at the Department of Women and Children’s Diseases

The Clinic of Women and Children’s Diseases has had a good cooperation with FOR over several years. At the FOR-operating room in the Clinic of Women and Children’s Diseases, mainly laparoscopic surgery is performed today. An Endo Alpha system has been installed including HD technology for imaging and visualization. Advanced platform for electro surgery with focus on vessel sealing is available.

Gynecological department is active in robot surgery, and robot is currently used both for the operation of general gynecology patients and for gynecological cancer. The da Vinci robot at St. Olav Hospital was obtained through FOR. In 2012, a second da Vinci robot was placed at Orkdal Hospital - as a gift from the Norwegian women’s public health association. Gynecologists operate with the da Vinci robot two days a week at St.Olavs Hospital and one to two days a week at Orkdal Hospital. Robot surgery is a good example of FOR activity; High-tech, innovative and has a great potential for the future. The department has conducted prospective studies related to ovarian cancer surgery (tumor reductive surgery) and surgical techniques in hysterectomies. Doctors at the department have recently concluded a prospective study on primary lymph nodes in endometrial and cervical cancer. Fluorescence camera attached to the da Vinci robot provides the opportunity to study this.

FOR assists the clinic with the mandatory EMU certification of The Clinic of Women and Children’s Diseases. This is placed in the competence portal so that the individual doctor can follow his own plan for EMU training and follow up when and it is time for renewal.

We look forward to continuing the good cooperation with FOR in 2017.

Kjell Åsmund Salvesen
Head of Clinic of Women and Children’s diseases
Photo: St.Olavs Hospital
## Operative activity FOR operating room 7
Department of Women and Children's diseases 2016

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternity unit</td>
<td>28 patients</td>
</tr>
<tr>
<td>IVF</td>
<td>25 patients</td>
</tr>
<tr>
<td>Gyn Cancer</td>
<td>11 patients</td>
</tr>
<tr>
<td>Gyn General</td>
<td>129 patients</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>193 patients</strong></td>
</tr>
</tbody>
</table>

FOR- Operating Room of the Future at the Department of Women and Children's diseases
Photo: Gabriel Kiss, FOR
For activity at the Department of Neurosurgery

Neurosurgical Clinic has a FOR-operating room where active clinical research is conducted. The research at the neurosurgery department is conducted in cooperation with the "Center for Ultrasound and Image guided Treatment". Research is directed by clinical needs and through a multidisciplinary clinical and technological approach; a more optimal patient treatment is developed. With regard to research activity at the FOR-operating room at the Neurosurgical Clinic, the research activity in progress is integrated into daily operative activities.

The department's most important research profile is the use of 2D and navigated 3D ultrasound in image-controlled minimal invasive neurosurgery. The technology is adapted to multiple applications, including pituitary surgery, brain tumor surgery, AVM surgery and hydrocephalus surgery. Today there are several projects where 3D ultrasound navigation is used for such interventions.

The «Visualization Project» is a project that tests new imaging technology of clinical images in the image guided neurosurgery during removal of brain tumors and aneurysms was performed for the first time in the world in 2016 in the FOR-operating room. CLEDIS technology from SONY was also tested in the operating room in 2016. The resulting image quality is impressive and higher resolution gives a better visual understanding of the operation area. The visualization project will continue in 2017.

A new ultrasound scanner for neurosurgery applications was purchased via FOR-NorMIT and is available at FOR-operating room at Nevro. The ultrasound scanner BK5000 is designed to be used intraoperatively with sterilizable probes and will be combined with the BrainLab Kick Navigation System for intraoperative navigation. Testing of the equipment has been carried out in cooperation with FOR-NorMIT.

FOR also assisted in 2016 with live transmission in connection with the annual international course for neurosurgeons "8th International Training Course - 3D Ultrasound and Neuro navigation" 14-15. June - arranged by the Competence Center for Ultrasound and Image guided Therapy Treatment at St.Olavs Hospital, NTNU and SINTEF. It was facilitated for successful live transmission in full HD and bi-directional audio communication on both course days. Both Geirmund Unsgård and Ole Solheim had interactive sessions with the participants on the course. In addition, an infrastructure for live video and audio data transmission was established which will make it much easier to send audio and video from the operating room to the auditorium in the coming years.

On behalf of the clinics, FOR has been given the task of arranging compulsory courses in electromechanical equipment (EMU course). Training and courses in electromechanical equipment for doctors are well established and all surgeons receive continuous offers and invitation to courses that are systematically registered and documented under the auspices of FOR. These EMU courses fulfil the requirements for EMU training for all LIS doctors and surgeons.

The cooperation with FOR has been positive and we look forward to continuing this good cooperation in 2017.

Geirmund Unsgård
Professor
Head of the Department of Neurosurgery
Photo: St. Olavs Hospital
| Operative activity at FOR operating room 3  
| Department of Neurosurgery 2016 |
|---------------------------------------------|---|
| Craniotomies/intracranial operations, vascular lesions and head trauma | 229 |
| Shunt operations | 19 |
| Operations on the spinal canal, spinal cord and nerve roots | 128 |
| Other operations: |
  - Spinal cord |
  - Nerve root |
  - Pain or dysfunksjon | 57 |
| **Total** | **433** |

FOR operating room, Department of Neurosurgery  
Photo: Gabriel Kiss
FOR activity at the Clinic of Ear-Nose-Throat, Eye- and Maxillofacial Surgery

Even though the news interest in having a FOR-operating room has slightly subsided, the FOR-operating room still stands out among the clinic’s nine other modern operating rooms. It provides a modern and high tech impression with special lighting and cockpit solution, and is a popular place to work and show to visitors. Since the opening of the Operating room in 2013, the FOR concept has stimulated technological focus in research projects, good audiovisual solutions, testing of new technological equipment and good logistics around the surgical patient.

I would like this year to give complements to FOR as a team-builder. By facilitating cooperation and bringing together different professional groups, creativity and innovation are promoted. The annual FOR seminar is an example of this. FOR is also responsible for the smooth cooperation with industrial equipment suppliers, which is comfortable and enables fruitful projects, innovations and progress.

The clinic is in continuous motion and is constantly seeking improvements in patient flow and logistics. By 2016, we have put a lot of effort in the launching of the Tonsil Registry, which was accepted as a national registry in September 2016. The Tonsil Registry is administratively assigned to St.Olavs Hospital, leading the project from January 2017. The Operating Room of the Future is a central arena for tonsillary surgery and one of our skilled FOR nurses is responsible for ensuring registration and patient flow around the operations.

We received a new FOR contact this year and look forward to further collaboration and research support at the clinic in 2017.

Mette Bratt
Head of clinic
Photo: St.Olavs Hospital
Operative activity at the FOR operating room 1
Department of ENT, Maxillofacial and Eye diseases in 2016

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional endoscopic sinus surgery (FESS)</td>
<td>53</td>
</tr>
<tr>
<td>Septal plasty</td>
<td>54</td>
</tr>
<tr>
<td>Concha plasty</td>
<td>12</td>
</tr>
<tr>
<td>Sialoscopy</td>
<td>16</td>
</tr>
<tr>
<td>Arthroscopy</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>150</strong></td>
</tr>
</tbody>
</table>
FOR activity at the Clinic for Orthopedic-, Rheumatology and Skin Diseases

The Clinic for Orthopedic, Rheumatology and Skin Diseases uses the Research Infrastructure Future Operating Room, FOR.

The FOR-operating room is used for example to major routine activities within prosthetic surgery. The operating room is equipped with LAF ceiling. In international research, it is a paradox that operations performed in LAF operating rooms seem to have a higher incidence of infections when one should expect the opposite. An important work that has started to investigate how different devices, such as the operation lamps, affect turbulence in the airflow.

In the meantime, a grant has been received for cooperation with SINTEF Applied Economics, around improvement of operational planning, investigating whether different algorithms or action rules can lead to higher operating room utilization. This work is going on, and is primarily a collaboration between SINTEF, Department of Patient Logistics and the Operating Department in Orthopedic surgery.

In spite of a lot of research on these issues, the practical application in most cases is rather unclear, and it is hoped that this project can lead to a concrete improvement in our activity.

We are planning to introduce navigation technology during spine and trauma surgery. This is a collaboration with the neurosurgeons, as we have established for neck surgery. This is a project between FOR and National center of competence for surgical treatment of spine and neck disease.

We hope that the technology in the FOR-operating room at our clinic will be optimized and improved emerging as a good innovation arena for further development of the orthopedic area.

Development of new treatment methods and medical technology is of great importance in the field of orthopedics. Over the past few years, several different research and development projects have been reported; indicating that FOR is a useful infrastructure. FOR, on behalf of the clinics, is leading the mandatory training and checkout of electro medical equipment for the surgeons and LIS. FOR arranges the courses and manages this registry through the competence portal.
### Operative activity FOR operating room 8
**Clinic of Orthopedic Surgery 2016**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary hip prostheses</td>
<td>84</td>
</tr>
<tr>
<td>Revision of hip prostheses</td>
<td>24</td>
</tr>
<tr>
<td>Knee prostheses</td>
<td>218</td>
</tr>
<tr>
<td>Other operations</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>325</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Research days</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>14 dager</strong></td>
</tr>
</tbody>
</table>

Mainly total prostheses of the knee are included in the fast-track project.

The pictures show simulation of an operating situation in connection with Air flow measurements project that has taken place in the FOR-living room in 2016.

Photo: Professor Guangyu Cao, NTNU
Medical Technology in the FOR operating rooms and FOR-NORMIT

During 2016 the medical technology in the FOR operating rooms has been serviced and has undergone minor adjustments and improvements. In addition software and hardware updates have been performed during 2016.

FOR AHL:

- The computer and the control unit of the robot arm (Kuka) connected to the ArtisZeego in the angio-lab have been replaced. The main cable between the robot and the DynaCT has been replaced, as well as the DynaCT’s operating system. Software upgrading, adjustment of the image processing pipeline and an application review have been completed.

FOR Gastro:

- An upgrade of the 3D visualization system for laparoscopic procedures has been performed. Software upgrade of the EndoAlpha system and upgrading of the EXERA platform in order to be able to use newer endoscopes has been carried out. The integration of the high-energetic platform for electro-surgery with the overall solution is ongoing.

FOR Nevo:

- Upgrade of display technology within navigation, with full support for HD and 4K resolutions. This can be integrated with today’s and tomorrow’s navigation technology. Testing of new display solutions with high-resolution and good depth perception, good ergonomics and proper rendering that provide significantly better image information has been ongoing.

- Visualization project with the development of new ways for visualization of medical images, with neurosurgery as a pilot. This is a pilot study on how medical images are distributed, visualized and how the clinician interacts with and extracts important image information. The next step is a CLED solution, a step on the way to 8K.

FOR Gyn:

- The software upgrade of the EndoAlpha system has been completed and the software of the EXERA platform upgraded. A new display was acquired; it has support for HD and can receive 4K images when they will be available. The high-energetic platform for electro-surgery is now integrated into the overall solution.

FOR ØNH:

- The software upgrading of OR-1 has been completed and subsequently the communication axis with medical technology department has been improved. The software of the optical and electromagnetic navigation platforms has been upgraded. A common virtual server is installed so that pre-planning within navigation can be carried out regardless of location. Several surgical fields have access to and can share the virtual server.
There are two da Vinci robots available, one for urology and one for gynecology. Gynecologists and urologists have gained good experience with the use of robotics and robotized procedures. Several surgical fields are interested in using the technology. One already sees increased interest in the technology and the hospital is challenged both on technology and space capacity.

FOR, in cooperation with the clinics, investigates long term solutions for this. Upgrades and service reviews have been completed on both robots in 2016 according to prior agreements. One of the da Vinci robots is part of the FOR-NORMIT infrastructure.

In 2016, there has also been a further development of fiber and IP-based communication solutions under the auspices of FOR. We are currently using IP technology through the research network (Uninett), which is used among other things in connection with networking meetings to several destinations in Asia, Europe and USA. Fiber communication from the FOR operating rooms has been established and further developed in order to enable live HD transfers. 4K has now come and we have already made some prototypes for imaging and visualization with the possibility of live transfers and 4K recordings.

Cooperation with the Medical Technical Department (MTA), HEMIT and Viju has been important for further optimization of the ICT infrastructure. It is now possible to drive full live transfers from all six FOR operating rooms to the Knowledge Center for example.

In addition to research-oriented patient treatment, the FOR operating rooms have been used for basic research and experimental trials. This applies to the use and development of navigation within neurosurgery, and ear nose and throat related procedures, laparoscopy and endovascular procedures. Testing and development of prototypes of medical technology has also been carried out in collaboration with research and international industrial partners. SINTEF employees and PhD candidates have used the FOR operating rooms for calibration, testing and setup of navigation equipment. Internally and together with industrial partners, an estimated 18 weeks have been used for testing of medical systems, quality controls, security controls, upgrades and validation. Faster image processing, as well as new applications have been introduced.

Integration of ultrasound images in the visualization pipeline and improvement of the user interface is a key research topic within FOR. All the planned equipment for FOR-NorMIT is now in place in Trondheim and available to researchers and clinicians, nationally and internationally. Overview of the technology is available through the website http://normit.no/ and can be booked and reserved there. The first part of the technology was acquired already in 2014 and continuously extended until the end of 2016. The technology is upgraded with new software according to established service agreements. It is important to keep the technology up to date so that it is sought after by researchers.
FOR-NorMIT infrastructure

The NorMIT infrastructure investment process in Trondheim was finalized during 2016 with the acquisition of two ultrasound scanners, a hydrophone scanning system and an EBUS bronchoscope.

The BK5000 ultrasound scanner from BK ultrasound is designed for an intra-operative setup with the addition of sterilizable probes. Three probes are available for use together with the scanner. They include a Burr-Hole, a craniotomy and a hockey stick probe. Furthermore, the BK 5000 can be combined with a BrainLab Kick system for intra-operative navigation purposes. A direct consequence of these improvements will be increased efficiency and better ergonomic conditions for the surgeons as well as improved patient safety and satisfaction.

The SURF ultrasound research system has been acquired from SURF Technology, Trondheim. SURF has the ability of transmitting two ultrasound waves simultaneously. A higher contrast ratio is achievable when compared to standard ultrasound machines, which allows more accurate detection of ultrasound contrast agents or micro-calcifications in diseased tissue. The SURF system aims to achieve targeted delivery of drugs by use of microbubbles, which will allow treatment of specific anatomic regions.

The AIMS III hydrophone scanning system from ONDA corporation is the latest generation hydrophone scanning system that enhances acoustic measurement productivity to map acoustic fields in liquids. User workflow is improved by productivity enhancements that save time in the measurement set-up, scanning, and reporting. Combined with Soniq Software, the user benefits from real-time plotting, automated FDA reporting, and improved positioning performance. AIMS III continues to be the de facto standard scanning tank for hydrophone-based measurements.
The EBUS bronchoscope is a linear endobronchial ultrasound scope for transbronchial needle aspiration from Olympus (EBUS-TBNA, BF-UC180F), specially designed for lymph node staging, including interlobar nodes, hilar nodes and the mediastinum. Its large channel accommodates the dedicated range of Olympus sampling devices and its increased 60 degrees scanning area allows sampling under full visual control. With its insertion capability and increased access to lymph node stations the EBUS-TBNA scope offers an alternative to mediastinoscopy. The EBUS scope’s impressive diagnostic value is complimented by compatibility to Aloka and Olympus ultrasound processors. With its detachable ultrasound cable design an ease of use is not only achieved in terms of system compatibility but also in reference to endoscope reprocessing.

<table>
<thead>
<tr>
<th>Users of the infrastructure</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of users</td>
<td>141</td>
</tr>
<tr>
<td>Total number of internal users (Users employed by the host institutions)</td>
<td>127</td>
</tr>
<tr>
<td>Total number of external users (Users not employed by the host institutions)</td>
<td>14</td>
</tr>
<tr>
<td>Number of students (6 Master, 12 Bachelor)</td>
<td>18</td>
</tr>
<tr>
<td>Number of PhD students</td>
<td>12</td>
</tr>
<tr>
<td>Number of scientists (permanent employment, post doc etc.)</td>
<td>65</td>
</tr>
<tr>
<td>Number of users from industry</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of projects ( funding) where the infrastructure has been used</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of projects</td>
<td>21</td>
</tr>
<tr>
<td>Number of projects with international funding (EU, Nordic etc.)</td>
<td>0</td>
</tr>
<tr>
<td>Number of projects with external national funding</td>
<td>6</td>
</tr>
<tr>
<td>Number of projects funded by the host institution (e.g. via the basic budget)</td>
<td>10</td>
</tr>
<tr>
<td>Number of projects funded by the industry</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1: Key figures for NorMIT’s node in Trondheim, FOR.

At NorMIT’s node in Trondheim

Research Infrastructure “Operating Room of the Future” (FOR) is focusing on the development of new treatment methods within image guided minimally invasive surgery and medical technology. It is well established within all surgical areas at St.Olavs Hospital, and the table above shows counting borders in the project. Here we see a large number of users of the infrastructure, as well as the number of projects, PhD candidates and how many users come internally or externally. The work in 2016 was to complete the establishment of the infrastructure, and in 2017 the focus will be on increasing the number of users.
**Medicine and media technology**

Medicine and Media Technology derives from the AV Arena Norway resource network at the “Operating Room of the Future” (FOR), which since the start of 2005 has had a strong focus on the development of imaged surgery and image processing. Digital media technology is an important driver in the development of these disciplines. This type of resource network is important for building bridges between digital media technology and health care tasks in learning and interaction and establishing projects to trigger medical and operational benefits in the healthcare sector. The Resource Network’s portfolio in 2016 has largely focused on improved health communication and telemedicine as well as building capacity for innovation in the public sector. The interaction with the oil sector remains an important factor for activity related to future telemedicine.

FOR has a good advantage as we have a strong media technology focus and are used to working with Norwegian and international industry partners and research communities. The media technology infrastructure is closely linked to clinical professional environments, which makes it easy to extract the transfer value between the environments, where we also play a key role in the planning of operating rooms and its design with focus on infrastructure and medical technology.

Medicine and media technology will be enriched in many areas, which will make us more attractive to many actors - and reinforce the organization’s position as an important research and innovation arena in health care.

Siv Lindia Ledsaak, chief physician at Fosen DMS, is investigating her patient with guidance from a doctor at the emergency unit at St.Olavs Hospital, Trondheim.

Photo: Berit Wiklund
Future telemedicine - cooperation with the oil sector

In June 2014, the project "The Future of Telemedicine in O & G" was terminated. The project is based on preliminary projects completed in 2013. Partners in the project were ConocoPhillips, Petrobras, IBM, St. Olav’s Hospital at the Operating Room of the Future and Emergency Medical Clinic, Medical Imaging Laboratory (MiLab), NTNU, Albert Einstein Hospital Brazil and Center for Integrated Operations in the oil sector at NTNU / IFE / SINTEF.

The project conducted studies of today’s workflow in telemedicine and explored opportunities for developing future telemedicine. This was through both the development and demonstration of a prototype for new telemedicine solution, as well as investigations of both safety aspects, as well as aspects of planning and implementation of new telemedicine practice offshore.

The project was developed based on needs drivers on the Norwegian and Brazilian shelf. The project provided a good basis for assessing future telemedicine solutions in the health service. The result of the project was the introduction and demonstration of a virtual survey room.

The project is now in a phase 3 in the period 2015-2017. Here, an upscaling of both prototype development and demonstration is planned. The collaboration room, the virtual research room, is continuously working throughout the entire period, which brings synergies to the decision-making interaction project in and between the treatment levels.
Virtual examination room (VER)

St. Olav’s Hospital, Fosen DMS and Røros Hospital, as well as inter-municipal emergency services have so far used fragmented solutions in the transmission of medical information in cases where interaction has been necessary. It may consist of fax, telephone, email and video conference. Patient information and necessary medical information have often been delivered orally, and at times much unstructured data.

As a result of a desire to get more structured data and better interaction and appropriate decision support, it is desirable to have a solution that can bring about this. When the pilot of the virtual investigation room was used in the offshore and Ekofisk project in collaboration with the IO Center, ConocoPhillips and IBM, work processes were done and how work processes had to be adjusted and tested to provide decision support from a specialist to nurses. A result of the first phases of that project was that the virtual examination room (VER) should be tested on land-based health as well. It has been done in the following projects:

St. Olav’s Hospital, Clinic for Emergency and Reception Medicine, works as a specialist in the project and will provide decision support for nurses at Røros Hospital and Fosen DMS, respectively. This is a user-driven innovation project, and development and testing are conducted in parallel. VER is an interaction platform for the exchange of medical data and a decision support system using automatic triage based on predefined parameters such as the Rapid Emergency Triage and Treatment System (RETTS) and the National Early Warning Score (NEWS).

In the figure to the right, Figure 1, VER appears as it appears for nurse seeking decision support, and specialist on the other, in Figure 2.

VER will thus serve as aiding for diagnostics and support.
The figure below, Figure 3 shows how vital parameters like blood pressure, pulse, oxygen saturation and breathing rate and other defined data are displayed in real time, as well as historically on the graph.

![Figure 3](image.png)

Figure 3. Patient data in real time, both historical and current data. Moving the mouse pointer over the graph gets you value at current times.

![Figure 4](image.png)

Figure 4. Here the specialist can enter an answer based on what he or she arrives. Often video is used addition for dialogue and to see the patient. Summary is done here in VER before the case ends.
Figure 4 shows how the specialist can acknowledge a response as a result of decision support. Most often, video communication is also opened. In the project, virtual video rooms were set up under the auspices of Norsk Helsenett for a multi-party conference. These are secure networks that can be used to discuss patient sensitive information and are encrypted. In the same way as interaction between Orkdal and Fosen, it takes place via video conferencing with video conferencing unit as of today.

The feedback received after the system has been tested is that this system can be used to diagnose patients virtual. Seeing vital data in real time, along with video and audio, are valuable information that will provide enough information for decision support. The decision-maker has sufficient information presented in the current solution, and looks at VER as a good interaction tool.

FOR will have further responsibility for developing VER as a clinical tool for decision support. The idea is that this should be available and ordered via HEMIT.

FOR has connected a master student in Industrial Design at NTNU in the autumn of 2016. This student will write his master’s thesis based on this VER system. The task is two-part; one focuses on the design of user interfaces and the further design of this. Point two is the development of an app, for example, tablets and smart phones. The Master’s thesis is scheduled to be delivered in June 2017.

Conclusion

VER is now a "package" that can be used as a collaborative tool for decision support and seamless sharing of medical information in and between treatment levels. HEMIT will take over the operation of VER from the summer of, and FOR will be the one who drives the further development of VER after this. The master’s degree, mentioned above, will help lift VER in the summer as well.
The National strategy plan for ICT 2013-2020

The Operating Room of the future is mentioned in the national plan for ICT 2013 - 2022. The Norwegian government has a strategy for research and development within ICT focusing on important areas where they want to spend resources in the years to come.

ICT in combination with medical technology is becoming more and more widespread. To improve growth and formation of values we need strong ICT groups in Norway and we are dependent upon research and development within this area. Although much is going on internationally, we need our own national expertise within the field.

The government has pointed at three focus areas of ICT research and development in the years to come:

- ICT of high international quality
- Business development
- Social challenges

Link to National strategy – ICT – research and develop

Courses arranged by FOR

EMU-courses arranged in 2016:

8th of January: EMU-course for the orthopedic department:
- High energy equipment
- Endoscopy
- Irradiation protection and use of C-arm for fluoroscopy

19th of April: EMU-course for ENT/Maxillofacial/eye:
- High energy equipment
- Endoscopy
- Radiation protection

Courses in the use of electro-medical equipment (EMU)
On behalf of the operating clinics FOR is conducting compulsory courses in the use of electro-medical equipment. In 1999 a new regulation regarding “Use and maintenance of electro-medical equipment” was passed. This regulation has its background in law on medical equipment from 1995. According to § 13 training and instruction in the application of such equipment is necessary because:

- **Personnel who are going to use electro-medical equipment must have training and instruction in the application of such equipment.**
- **They should know potential side-effects connected to the application of electro-medical instruments and know how to prevent them.**
- **The training program must be systematic and include documentation.**

The Systematic training program must include:

- **Training when new equipment is introduced.**
- **Training of new employees.**
- **Maintenance of the knowledge achieved during this training program.**

At present the training program including the documentation is well established at all operating clinics at St. Olavs Hospital. All surgeons, including surgeons in training as well as staff surgeons, are getting invitation to the courses as part of the continuing medical education.

Competence portal
All courses in electromechanical equipment and infection protection are now assigned to the individual doctor and LIS in the competence portal. Everyone can now see which courses are valid and what courses need to be renewed. When you click on the course in the competence portal, you will automatically come to the course in the learning portal, if it is an e-learning course. Initially, this applies to infection protection and parts of the radiation protection course. High-energy devices and endoscopy, as well as the use of C-arm is still classroom teaching.

Staff
Medical personnel affiliated to FOR is going through annual certification in compliance with national regulations regarding use and maintenance of electro-medical equipment. All surgeons at St. Olavs Hospital are also going through courses on an annual basis regarding the use and maintenance of electro-medical equipment. The personnel at FOR is including so-called super-users having special focus on modern, advanced medical technology. They need to go through refreshing courses on a regular basis.

The personnel at FOR is contributing to training of personnel from other departments at St.Olavs Hospital as well as personnel from institutions focusing on clinical procedures, research and application of medical technology.

FOR has through visits and hospitants from other hospitals in Norway helped to provide important information and training on new technologies, methods and integration of laparoscopic/ endoscopic surgery. Organization and design of operating rooms has also been the subject. At the simulator course organized by the National Center for Advanced Laparoscopic Surgery (NSALK), FOR has been used as a venue for transmission of operating procedures and information on the integration of new equipment.
During the past year, the staff at FOR has completed various courses and studies in professional development, leadership development and research.

Students
Since 2005 FOR has had excellent cooperation with University College of Sør-Trøndelag (HiST). On a regular basis we had presentations for students at the Department of Health and Social Work, for operating room nurses and anaesthesia nurses as well as radiography students and students within bio-engineering. This has resulted in several bachelor degrees, which have been performed as a cooperation with FOR in our operating rooms. FOR is also taking care of teaching the use of electro-medical equipment for several of these students.

Other courses arranged by FOR
19.02.16 – Course for bachelor students, bioengineering, radiography and nursing, NTNU. Arne Hansen, Geir Andre Pedersen and Liv- Inger Stenstad

13.04.16 – One day course for master students in clinical health science “Overweight and health”. Live-transmission from FOR operating room gastro. Ronald Mårvik and Liv-Inger Stenstad

Visits at FOR
April 20: Smith & Nephew, visit from research director Beate Hanson and R & D team. Briefing on FOR-NorMIT research infrastructure. Jan Gunnar Skogås, FOR

April 21: Apple and IBM, visit from Erling Teig, CEO Apple Norway and Olav Frøseth IBM. Focus ICT Health and Collaborative Projects FOR. Jan Gunnar Skogås, Gabriel Kiss, Geir Andre Pedersen, Liv-Inger Stenstad, FOR

4th of May: Siemens visit. Martin Ostermeier, Anne Figel, Magne Fiskvik, Vebjørn Jentoft

Guided tour ENT, Nils Petter Fossland, AH-1F, Asbjørn Ødegård.
Liv-Inger Stenstad, Jan Gunnar Skogås, FOR


October 26: Visit of the Norwegian Association for Automation. Lecture and tour NSALK v / Kirsten Rønning, The simulator center v / Petter Aadahl, FOR-operating room at AHL v / Frode Manstad-Hulaas FOR- operating room at Gastro v / Ronald Mårvik. Jan Gunnar Skogås, Geir Andre Pedersen, Liv- Inger Stenstad, Gabriel Kiss and Marianne Haugvold, FOR

Visit by the Norwegian Association for Automation
Photo: Marianne Haugvold, FOR
Experimental surgery

All FOR operating rooms are authorized for experimental surgery including animal research. Such experimental procedures can be ordered at FOR who will then organize them. This arrangement is well established among clinicians and scientists. We have a “package” where FOR is organizing and planning the animal experiments in collaboration with Department of Comparative Medicine (AKM). FOR has trained and authorized personnel assisting during the whole process.

Personnel who is planning or taking part in animal experiments must go through courses in animal experiments approved by the Norwegian Food Safety Authority. An important part of this course is to understand laws and regulations connected with the use of animals in medical experiments. The regulation regarding animal experiments assumes that all persons planning or performing such experiments should have passed the courses and be registered in the electronic system (FOTS) of the board for animal research. Both the responsible scientist and his co-workers involved in the practical performance of the experiments, including those who are taking care of the animals, should be included in the registration and have documentation that they have passed the course in animal experiments, category C.

Two days of experimental surgery were completed in 2016:

18th of April: Mitral valve anchoring
Jacob Bergsland and Nicolai Hiort.

April 22nd: Mitral valve anchoring
Jacob Bergsland and Nicolai Hiort.

Clinic Director at Vivantes International Medicine, Prof. Dr. med. Hüseyin Ince conducts a pilot study attempting to repair the mitral valve using a catheter method.
Photo: Nikolai Hiort
**Research Collaborations**

**National and international partners**

Together with the Intervention Center (IVS) at Oslo University Hospital, FOR has established the National Research Infrastructure, NorMIT Norwegian Center for Minimally Invasive Image Guided Therapy and Medical Technologies, which now has its infrastructure in place with several ongoing projects. The NorMIT infrastructure is available both nationally and internationally, as part of phase 1 of the project.

SINTEF is one of FOR’s most important collaboration partners. The cooperation is among other things built around the "National Center for Ultrasound and Image Guided Therapy". FOR has also a very good collaboration with NTNU at the Department of Circulation and Medical Imaging, Department of Energy and Process Engineering, Department of Design, Department of Mathematical Sciences, Department of Electronic Systems and the Department of Technical Cybernetics. The students at the Faculty of Health Sciences at NTNU use the FOR infrastructure for tasks related to their bachelor’s and master’s degree in collaboration with FOR. Various competence centers such as the "National Center for Ultrasound and Image Guided Therapy" and the "National Center for Advanced Laparoscopic Surgery", NTNU Technology Transfer (TTO) and Center for Interdisciplinary Research in Space (CIRiS) are important partners and the synergy effect of this collaboration is important to maintain since it will ensure fruitful research in the future.

Furthermore, FOR has a good partnership with a number of industrial partners: Sony, Medtronic, Brainlab, Intuitive, Siemens, Stryker, Karl Storz, IBM, Apple, ConocoPhillips, Total, Olympus, and Smith & Nephew. Good practices and guidelines for collaboration with industrial partners have been developed together with legal experts in this area.

FOR has an established joint research project with several international actors such as Vanderbilt University Medical Center in Nashville, TN, USA. Together we investigate what is the impact of new treatment methods on technological solutions and choices made in the operating room. We also want to collaborate on efficient use of ICT in the operating rooms in order to optimize workflow and patient flow. We also work with Albert Einstein Hospital in Sao Paulo, Brazil. It is mainly about telemedicine and "decentralization of specialist healthcare services". There are many other international players wishing to cooperate with FOR. So far, we have focused to establish research collaborations with the Massachusetts General Hospital in Boston, the Operating Room of the Future in Tubingen and research groups at Krakow University Hospital in Poland. There has also been established a collaboration with the Yonsei University Health System, Seoul, Korea. Handling of the elderly patient wave, the intelligent hospital and the transmission of high quality medical information are some specific projects that have been started and which we want to focus on in the next few years. In 2016 a collaboration project was initiated with UFF Universidade Federal Fluminense in Brazil, where telemedicine via holograms is the main focus.

FOR also collaborates with organizations such as the European Association for Endoscopic Surgery (EAES) and the Society for Minimally Invasive Therapy (SMIT) and Technoprot in Trondheim.
The Operating Room of the Future (FOR) is the arena and infrastructure provider for several ongoing research projects, including projects at the national center of competence for ultrasound and image guided therapy (www.USIGT.org). SINTEF is a key and important research partner and partner for FOR and USIGT. Thomas Langø at SINTEF has a coordinator position at St. Olavs Hospital related to this center. One of the largest activities in 2016 was linked to activities of the above-mentioned competence center, which is national and appointed by the Ministry of Health and Care. The center uses FOR as the arena for a number of clinical and technological research and development projects ranging from technology development, prototyping and clinical trials / studies of new solutions which improve patient care. In 2016 there were 8 PhD projects in progress and 7 ongoing Postdoc research projects. About half of these have a workplace at SINTEF, having a shared position between SINTEF and NTNU. Often, a technologist and a clinician are working together on PhD projects related to the same topic, which illuminates the problem from both a clinical and a technical perspective. There were published 24 scientific papers with peer review at USIGT in 2016, some from projects conducted at FOR, St. Olavs Hospital.

Through several user-driven projects supported by the Research Council and EU, the USIGT competence center has been an important competence environment for innovation and industrial cooperation. The competence center has a broad national and international network and extensive activity related to the development and dissemination of expertise and knowledge, one of the core tasks of the service. Through participation in several EU projects: VECtOr, IIIOS Marie Curie Initial Training Network, 3MICRON, FUSIMO, MISTELA, RASIMAs, TRANSFUSIMO, and the recently awarded project HiPerNav ITN, important expertise from international academic environments has been “imported”, while at the same time generating and contributing to the spread of local expertise both nationally and internationally. St. Olavs Hospital at FOR and SINTEF have applied for a new ETN EU project, ORConnect, in January 2017, in collaboration with 10 other European recent groups.

The competence center focuses on image guided minimally invasive therapy with areas of interest related to surgery, neurosurgery, laparoscopic surgery, pulmonary medicine and radiology/urology. In addition to the use of ultrasound, navigation is also an important field of research in the competence center. Here you will find The CustusX Navigation Platform, developed and maintained by SINTEF, which is available as an open source package (www.CustusX.org). The purpose is to make the diagnosis better and the treatment safer. This platform will now be disseminated nationally through the NorMIT infrastructure project and internationally as an open source platform in the form of customized versions for clinical applications. An example of the latter is Fraxinus, a project that will create and distribute a free software package for bronchoscopy guidance and thus making the diagnosis of lung lesions, easier making.

The activity of the national competence center for ultrasound and image therapy is a good example of how the future operating space can support research, development and testing of new technology and methods, while strengthening national and international cooperation. In addition, FOR contributes with expertise related to courses and publishing popular science articles in close cooperation with SINTEF. SINTEF also brings considerable expertise into the collaboration and utilizes its basic funding for strategic efforts to develop new technology for minimally invasive surgery / therapy.
Operating Room of the Future and Institute of Circulation and Medical Imaging, DMF, NTNU

An expectation of increased clinical research and innovation in the future.

Digitization and introduction of new medical technology will be central to Norwegian healthcare in the future. Then there will be a need for a safe and secure arena for development and testing of new technology and new solutions. The Future’s Operations Room and NorMIT is an infrastructure that allows pilotage and testing of new technologies for better patient treatment, logistics and collaboration between different professions with a common goal of good patient care. Support and good infrastructure for research and innovation are crucial for clinicians to be able to make use of research as a tool for their own competence building.

In 2016, a lot of interesting and good research was done in the Operating Room of the Future, both in collaboration with industry and through various clinical research projects and PhD work. At the same time, we see that there are opportunities to do more, especially in terms of innovation and cooperation in a merged NTNU. We are therefore looking forward to an exciting 2017, where we can increasingly realize interdisciplinary cooperation that can develop new solutions for better patient care. With new health education under the same NTNU umbrella, we also see great opportunities for better education including practice placements and especially the increase in MSc and BSc assignments that relies on the needs and challenges facing the workplace and addressed within this infrastructure.

We hope for the years to come that the Operating Room of the Future will be an even more important partner for international cooperation and EU research. An active researcher easily enters the research front and acquires important competence through his own research work, daily reading of scientific articles, is active in academic discussions in research networks and through conference participation nationally and internationally. For a researcher, import and development of new knowledge is ongoing in cooperation with good colleagues and partners nationally and internationally. We wish through the infrastructure to be attractive for importing good knowledge and expertise as well as contributing to developing new knowledge and technology that is competitive internationally. Developing new ideas for industrialization and cooperation with existing business is important in order to offer patients the best patient treatment. Also in this area, we have high expectations for the Operating Room of the Future and NorMIT in the coming years. We are looking forward to it.

Toril A. Nagelhus Hernes
Former Head of Department, Department of Circulation and Imaging, DMF, NTNU
Current Prorector Innovation, NTNU
Professor of Medical Technology
Photo: NTNU
FOR in the future

The research infrastructure “Operating Room of the Future” (FOR) has now been running for 11 years, where the main focus is surgical research and development towards clinics operating in the field of image guided minimally, invasive treatment. Today, the infrastructure consists of 6 operating rooms, with the overlay of an AV-ICT structure that enables live transfers and interactive communication at full HD and eventually 4K. Further refinement of intraoperative imaging will take place. 3D visualization manufacturing and holography will probably be routine. The image guided minimally invasive treatment represents one of the major areas of innovation in the specialist health service. Such procedures have been an important factor in creating a more efficient and gentle treatment of the patient. Several surgical procedures are now being carried out as day surgery and the patient is returning more quickly in everyday work. It is likely that this trend will continue in the years to come and that open surgery will increasingly be replaced by minimal invasive procedures. At the same time, the panorama of disease will change over time.

There is an increasing number of elderly people in the population. Open surgery in elderly patients’ represents specific challenges because the risk of complications is higher than in younger patients, and it takes longer time for patients to recover after treatment. Particularly with regard to these patients, image guided minimally invasive treatment is an advantage.

A significant number of hospitals are renovated and planned in Norway and in other countries. The operating rooms are expensive to build and to run. We want to make experience and be a leader in the field so that we can optimize our investments. We focus on architecture, material use, ergonomics, ICT solutions, logistics and health economics, so we can build cheaper and organize more rationally. It is important to do this in a systematic manner getting reliable knowledge of various conditions at the operating departments. There is still a need to structure the testing of equipment and technology in operating departments, and FOR will continue to provide support for the creation of contracts, implementation and evaluation of the projects.

The work to involve new disciplines will continue in 2017, and we are pleased that navigation technology is now applied at the ENT department and the department of pulmonary diseases. We hope that new technology will give us better opportunities for early diagnosis of tumors in the lungs. The need for multifunctional intervention rooms and the El-Phys lab is increasing. This will have significant consequences for future operating capacity within minimally invasive image guided intervention at the hospital.

The capacity of today’s FOR-operating room at AHL is now fully booked. We hope for two common FOR-operating rooms, which will be used by several disciplines, because there is an increasing need for hybrid interventions in radiology, cardiology, surgery, thoracic surgery and pulmonary medicine.

Our goal is to get more international fellows at FOR. These fellowships are funded externally. This has made it possible to maintain good scientific activity despite a low basic budget. FOR has goal of having two PhDs and four master degrees a year. In the years to come there will be an increasing need for master degree and bachelor projects. By creating a number of projects for medical students, we can also get in touch with future candidates for fellowships. Here, FOR can be a good platform.

In 2016 FOR has also continued and developed a systematic and documented program for the training of doctors in the operating clinics, in the use of electro medical equipment, EMU. The introduction of new medical technology in patient treatment results in an increased need for personnel training. Such training is also required by law, and systematic training of those who operate the equipment involves, among other things, training on new equipment, training of new employees / temporary staff and maintenance of the training given. All physicians at operating departments are now offered and invited to courses, which are systematically registered and documented. The training has now been included in the established Competence Portal in 2016, so that the employees have full status overview. The system has the possibility of integration with other systems and can enhance the process of e-learning. This is an innovation project that has great transfer value to other health institutions and health regions.

FOR has a close cooperation with several institutions like international industry, clinical departments and technology groups.
The most important collaborators are St. Olav’s Hospital, the Faculty of Medicine and health science at NTNU and SINTEF. Various centers of competence such as the “Center for Ultrasound and Image guided Therapy” and “National Center for Advanced Laparoscopic Surgery”, NTNU Technology Transfer (TTO) and the Center for Interdisciplinary Research in Space (CIRiS) are key partners and it is important to take care of the synergy effect of this collaboration the future. The cooperation with SINTEF on navigation technology equipment continues, and we have great expectations for the use of steerable wires and catheters for endovascular treatment. In pulmonary medicine, one has used navigation in conjunction with endoscopy and endobronchial procedures. Robotic surgery is also a field where FOR is involved. New techniques for the treatment of patients with morbid obesity are tested. We are looking forward to collaboration with the clinic for medical imaging, and will focus on ultrasound control of patients who have received endovascular stent graft for aortic aneurysms.

The operating room of the future has been, and is, an internationally preferred collaborative partner in particular within imaging and visualization technology for medical use including minimally invasive treatment. We want to strengthen international cooperation and several international groups wish to cooperate with FOR. So far we have concentrated on Massachusetts General Hospital in Boston, the Future’s Operations Room in Tubingen and research groups at Krakow University Hospital in Poland. We cooperate with Vanderbilt University Medical Center, Nashville; TN. FOR also collaborates with organizations like EAES and SMIT. Furthermore, cooperation with Yonsei University Health System, Seoul, Korea has been established. New of the year 2016’s collaboration with UFF Universidade Federal Fluminense in Brazil, which resulted in a MoU and collaboration on telemedicine and holography.

We wish the Operations Room of the Future (FOR) to be a research infrastructure of good international quality. The goal is to increase the quality and scope of research relevant to FOR. FOR will also be in the international forefront of image guided minimal invasive treatment. St. Olav’s Hospital and FOR are therefore international pioneer in the intercept between digital media technology and new applications in the field of image guided minimally invasive treatment. FOR is currently conducting development projects on quality improvement for minimal invasive surgery in all surgical fields and is well suited to conduct such innovation and development work. FOR has contributed to set the standard for minimal invasive treatment in an international context. New treatment principles such as genetic therapy, nanomedicine and tissue engineering (TE) will be important treatment modalities in the future. These are areas that FOR is turning the attention to through a multidisciplinary approach.

NorMIT «Norwegian Center for Minimally Invasive Image Guided Therapy and Medical Technologies» as a infrastructure and platform may bring us further nationally and internationally. This platform has been developed between FOR and the Intervention Center, Oslo University Hospital, Rikshospitalet and supported by funding from the Norwegian Research Council. The purpose of the collaboration is to improve patient treatment and raise the quality and scope of research and innovation thereby putting Norway on the map internationally. In 2016, the focus has been establishing the structure and acquisition of equipment.

Jan Gunnar Skogås
Managing Director
Research infrastructure “Operating Room of the Future” (FOR)
Photo: Private
Scientific Work

Post doc. – ongoing

Heidi Gilstad
Researcher and postdoc at the Department of Health Informatics, Department of Neuromedicine.
In the postdoc project "Health communication in a digital everyday situation ", developed in collaboration with the Operating Room of the Future, she studies patients' experiences of communication during their stay in hospital. The project is theoretically rooted in linguistic and discourse analytical perspectives on information dissemination and communication on health. Heidi is also a project leader for "Smart Digital Health Communications", funded by the Cooperative Body, as well as for the NFR-funded network project "Strengthening the eHealth Expertise and Services for Citizens - Focusing on eHealth Literacy and Communication."

Håkon Olav Leira
Håkon Olav Leira has a 50 % postdoc position for 6 years at ISB, DMF, and NTNU. He is also a consultant at the department of pulmonary medicine. His main research topic is on bronchial carcinoma, especially navigation combined with bronchoscopy. This is a part of USIGT, FOR and NorMIT. He is also active in the planning of the new FOR operating room at the department of pulmonary medicine.
Juan A. S. Margallo, Minimally Invasive Surgery Center (Caceres, Spain) / SINTEF
The main objective of the project is the development, integration, and validation of a surgical navigation model for assistance in pancreatic surgery. This model will provide a set of surgical training and assistance tools in order to improve the patient safety, as well as the accuracy and surgical outcomes obtained in this type of laparoscopic interventions.

Reidar Brekken, NTNU / SINTEF
Endovascular treatment is a gentler alternative to open surgery. X-ray imaging is routinely used to guide endovascular treatment. In this study, we are working on developing ultrasound-based guidance methods, which will reduce the use of X-ray information, and, in particular, the use of X-ray exposure agents that can pose a major strain on the kidneys of the individual patient. By using 3D (real-time) real-time imaging, you also get depth information that may be advantageous during the operation, compared to two-dimensional image. The main focus of the project has been to develop solutions for combining real-time ultrasound information with preoperative CT images providing better overall view of blood vessels.
Daniel Høyer Iversen, NTNU / SINTEF
3-D Ultrasound imaging for improved detection and quantification of blood flow. The primary goal of this project is to develop methods for improved 3-D ultrasound imaging of blood vessels. In surgery, information of blood flow is important to identify and avoid damage to important vessels.

Sebastien Müller, NTNU / INM / SINTEF
"Project Title: MultiGuide; Development and Security. The main focus of the postdoctoral program will be the implementation of feasibility and usability (human-machine interaction) studies for quality assurance and documentation of the operating procedures, as well as being technically responsible during the clinical studies. The postdoctor will be responsible for the technical validation of the new display device developed to the MultiGuiden with a particular focus on accuracy analysis of the navigation device. Furthermore, the clinical validation for each application is carried out in close collaboration with the clinics. For each clinical study, he will also be responsible for recording adverse device effects (ADEs). These are adverse events that might occur due to error or lack of procedures, software or medical device (MultiGuiden). These registrations will be based on "Clinical examination of medical devices for human subjects - Good clinical practice, ISO 14155". Such registration is required for future CE marking of the MultiGuide.

PhD - ongoing

Cecilie Våpenstad
"Tools and methods for skills training in minimal invasive surgery – using simulators, ultrasound and navigation.” Technological PhD candidate. Looking at how simulators and simulation can improve and quality assure surgical skills and surgical teamwork within endovascular and laparoscopic procedures. Supervisors: Toril A. Nagelhus Hernes, Ronald Mårvik and Petter Aadahl

Geir Arne Tangen
"Enhanced Minimally Invasive Therapy”. Technological PhD candidate. In 2016 he worked on the development / testing of steerable catheters integrated with navigation technology for endovascular procedures. They also conducted a study to examine the method that ensures more accurate correlation between image information from CT and blood vessel anatomy by guiding catheter procedures. This can be used to simplify the integration of navigation technologies in endovascular procedures and ensure more accurate maneuvering of catheter and guidewire in complex anatomy. Supervisors: Toril A. Nagelhus Hernes and Petter Aadahl
Kent Are Jamtøy

“Botulinum toxin type A blockade of sphenopalatine ganglion in chronic rhinosinusitis with nasal polyposis”. Injections against ggl. sphenopalatine with Multi Guide in 10 patients with intractable polyposis. The inclusion and interventions of patients in the study has started. Scheduled completion in 2017.

Mads Henrik Moxness

Modeling of Obstructive Sleep Apnea by Fluid-Structure Interaction in the Upper Airways – «Modellering av øvre luftveier ved obstruktiv søvnappne».

The project includes development of a new optical navigated tool for use with targeted injections and samplings. The tool "Multi Guide" is patented and developed in cooperation with NTNU TTO and medical department, MTA. Developing of prototype number 2 is soon finished.

In the use of Multi Guide enters into an intervention study to explore the effect of targeted blocking ganglion of sphenopalatine in pterygopalatine fossa with botulinum toxin in primary headaches. The project is a collaboration with neurological and radiological departments.

The Research Council has allocated 10 million to the project. A research project between DMF, Faculty of Engineering Science and Technology and SINTEF to develop a 3D model and a computer simulation of the conditions in the upper airway in patients with obstructive sleep apnea before and after nose surgery.

The model will be based on CT and MR images and airway measurements in patients. In one part of the project, 25 patients are operated at ORF and results correlated between measurements postoperatively in patients and results from the model.

The goal is to find general principles for the impact of nasal surgery on OSAS and the ability to predict the outcome of treatment in the individual patient.

- Simulating changes in upper airway by nasal operations on patients with OSAS
- Medical plan: Operate at least 25 pas - MR / CT before / after
- Separate research in patients with OSAS
- Results of surgery and epidemiology

The project period is three years and is a PhD project for Mads Moxness.

Supervisor ENT: Ståle Nordgård

The project starts in 2017 and also includes 2 PhD at IVT, 2 masterstudents and dissertations about validating data model.

The project has its own website: www.osas.no

Daniel Fossum Bratbak

“The Sphenopalatine project”

The project includes development of a new optical navigated tool for use with targeted injections and samplings. The tool "Multi Guide" is patented and developed in cooperation with NTNU TTO and medical department, MTA. Developing of prototype number 2 is soon finished.

In the use of Multi Guide enters into an intervention study to explore the effect of targeted blocking ganglion of sphenopalatine in pterygopalatine fossa with botulinum toxin in primary headaches. The project is a collaboration with neurological and radiological departments.

We have received support from FOR for purchasing our own navigation system, which enables us to develop and offer treatment as an outpatient procedure. Pilot study is conducted on Botox blockade of ggl. sphenopalatine in patients with therapy-resistant cluster headache (10 patients) where the results are being published. A similar study in patients with migraine performed

A multinational, randomized, placebo-controlled study is scheduled to start in 2017, considering the effect of botulinum blockade of ganglion sphenopalatine by chronic cluster headache.

Supervisor Neuro: Erling Tronvik og ENT: Ståle Nordgård

The project has its own website: www.multiguide.no
Camilla Berge
“Abdominal aortic aneurysm repair
Factors influencing early and late mortality”
Clinical PhD candidate
The thesis deals with factors affecting early and long
term mortality after surgery for abdominal aortic
aneurysm. It includes both open surgery and
endovascular treatment. In particular, the focus is on
female patients. They have higher mortality during
surgery for rupture than men. And aneurysm rupture
at lower diameter in women than in men.
Long term survival improved generally over time.
Accompanying conditions like cerebrovascular disease,
diabetes, COPD and renal failure affected long-term
survival in a negative direction. Female patients had
more autoimmune diseases than men. But there were
otherwise no differences in morbidity or incidence of
postoperative complications that could explain the
higher early mortality in women.
Patients with elevated white blood cell count
preoperatively had generally higher early mortality
than those who had normal white blood cell count.
Supervisors: Torbjørn Dahl, Hans Olav Myhre and Anne
Irene Hagen

Anna Rethy
“Navigated 3D laparoscopic ultrasound in treatment of
liver tumours.”
Clinical PhD candidate.
Rethy investigate the use of laparoscopic ultrasound
in primary tumors and metastases in the liver. She has
also studied position changes in solid bodies by
establishing air in the abdominal cavity for laparoscopic
surgery, and how navigation technology can then be
used as well. In addition, she has worked with
multimodal live models to simulate tumors and test
multimodal imaging and training with laparoscopy and
 navigational instruments.
Supervisors: Ronald Mårvik and Thomas Langø

Lars Eirik Bø
Back pain surgery
In this PhD project, new methods for supervising
surgeons have been established for back surgery.
Today many such interventions are directed solely
through the use of X-ray, but one wants to develop
methods that allow a combination of ultrasound and
MR imaging instead. In this way, the surgeon gets
three-dimensional and more detailed images to
navigate, as well as reducing the use of X-rays in the
operating room. In the last part of the project, Bø has
collaborated closely with a research group at The
University of British Colombia, which has developed a
method of recording MR images of the back to
corresponding ultrasound images.
By 2016, Bø has worked to integrate this method with
our image guidance systems. In addition, he has
worked to optimize the MR images for registration, and
a trial of the method is planned for patients. This trial,
which forms the final part of the PhD project, is now
approved by REK and is scheduled for completion in
the first half of 2017.

Rita Elmkvist-Nilsen
“Mapping Brain Plasticity”
Rita Elmkvist-Nilsen’s PhD project examines the
formative role of newer image mediating technologies
play as knowledge producing, diagnostic and
therapeutic tools in neuroscientific research practice.
The project focuses on newer approaches in cognitive
neuroscience that regard the brain as an adaptive and
dynamic body with plastic potential and actualize
through diffractive reading later human scientific
perspectives on human perception and cognition as
bodily anchored, relational, situated, action oriented,
and shaped by technological Mediations.
Supervisors: Aud Sissel Hoel and Anne Beaulieu
Hanne Sorger
“Development of a navigation system for bronchoscopy”.
The main objective of the project is to improve minimally invasive lung cancer diagnostics using a new Image guidance system based on electromagnetic navigation and multimodal image fusion. In the case of lung cancer, the patient’s prognosis is most important for the spread of the disease to mediastinal lymph nodes, which excludes radical surgery. Endobronchial ultrasound with Finsula aspiration from lymph nodes (EBUS-TBNA) is the first choice in the stage division. New Clinical guidelines now recommend systematically EBUS-TBNA also of small (<5 mm) mediastinal lymph nodes if the patient may be appropriate for curative lung cancer treatment.

Future EBUS TBNA will therefore be increasing technically challenging, with demands for effective and gentle procedure so the patient can be examined on an outpatient basis and in awake condition.

We have developed a prototype EBUS bronchoscope, where a millimeter-sized sensor attached to the tip allows tracking of the ultrasound head position in an electromagnetic field around the patient’s chest. The patient’s own preoperative images (usually CT) are imported into the navigation program, automatically registered to the patient’s position on the operating table, and serves as a 3D map for sampling of the sampling equipment. The ultrasound images from the EBUS bronchoscope are merged with preoperative CT images in the navigation program, and contribute with Real-time information during the survey (see figure). The bronchoscope can navigate quickly and accurately to each individual lymph node for sampling. Diagnostic precision and success rate for EBUS-TBNA can be increased. More precise and effective selection of curable lung cancer patients will be possible without the need for invasive methods with higher complication rate.

Photo: Private
Application of navigation technology in combination with 3D models from radiological images partly overcomes the difficulties in minimally invasive interventions, such as reduction of eyesight, lack of agility and tactile feedback. The concept of navigated surgery is that augmentation, tracking, and registration techniques could be used to superimpose preoperative 2D, 3D and possibly 4D models (deformable from respiratory association) onto a video endoscopic image and that this will improve image guided therapy with multimodal medical imaging. A precise minimally invasive diagnostics requires methodical preparation involving preoperative three-dimensional (3D) model visualization of vital anatomic structures and also intraoperative real time imaging for more accurate guidance. One of the navigation methods is diagnostics through navigated bronchoscopy. The purpose of navigated bronchoscopy is to steer the instrument tip from the trachea into a lesion/tumor target for an inspection or biopsy. The study is focusing on expansions of existing visualization procedures in navigation bronchoscopy i.e. technology regarding map display during computer aided navigated virtual bronchoscopy. The thesis follows the development of the anchored to centerline curved surface that represent a route to the target from trachea to lesion within the airways, slicing the endoluminal view in half.
Research Program for medical students

At the Faculty of Medicine and Health Sciences, a separate research branch has been established as alternative to the ordinary curriculum in medicine. The research line entails two additional 6 months terms allocated for research only, and that research is organized in parallel with the medical studies. The research line is an offer for medical students interested in deepening research and a possible future research career, possibly in parallel with clinical activities.

Erik Nypan

Three dimensional visualization and navigation for endovascular procedures.

The project deals with navigation systems for use in endovascular navigation, especially considering the aorta. The goal is to compare navigation systems iPILOT (Siemens) and CustusX (SINTEF) for endovascular use. The first part of the project compares the accuracy of registration algorithms used by navigation systems. The algorithms used to pair preoperative data with intraoperative data. Data for phantom is collected, and during the fall and spring patient data should also be collected. In the last part of the project it is planned to conduct animal studies on pigs. We will then look at navigation systems in a clinical setting by looking at how easy they are to use, the use of contrast medium, the total radiation dose etc. The project is conducted at the FOR operating room in the AHL.

Supervisors: Frode Manstad-Hulaas and Reidar Brekken

Henrik Runde

The study "Mortality, physical function and quality of life in patients treated in the standardized patient course" Fast-track hip fracture "is a prospective cohort study. The purpose of the study is to evaluate how the fast track process affects mortality and further map factors that may affect physical fitness and independence of the patient group. The study will follow a group of 100 patients with hip fractures treated at the Orthopedic Department, St. Olavs Hospital. While the patient is present at the department, pre-fracture functionality and quality of life are scored with EuroQol EQ-5D-5L, and two-day post-operatively performed short-term physical performance (SPPB) by a physiotherapist. Other information, such as medical history, x-ray findings and information related to treatment, is recorded in the registry chart for hip fracture patients.

The patient group will be called in for control after one year when EQ-5D-5L and SPPB are again performed, in addition to examining the patient’s walking pattern in ganglab.

Main supervisor: Lars Gunnar Johnsen
Co-supervisor: Trude Basso
Master degrees -finished in 2016

Lise Hagen
Lise Hagen completed her Master's thesis in Clinical Health Sciences, Applied Clinical Research 29.08.16. The Master's thesis has the title "Postoperative wound infections, an observation study at St. Olavs Hospital, Dept. Røros." The aim of the Master's program is to map the proportion of patients receiving postoperative wound infection after day surgery at St. Olavs Hospital, Røros Hospital. It includes 600 patients. These are interviewed with a phone call 30 days after surgery to ask for signs of infections. One study will also look at the occurrence of such infections in the context of different risk factors. Supervisor: Ivar Rossvoll

Liv-Inger Stenstad
Liv-Inger Stenstad at the Operating Room of the Future completed her master's degree in Clinical Health Sciences, Applied Clinical Research 09.11.16. The master thesis has the title "Information dissemination to patients who are going through an image diagnostic examination".

This is a qualitative study of informants from both the Rikshospitalet OUS and St. Olavs Hospital, and the purpose was to look at what patients prefer when it comes to receiving information in advance of a demanding image diagnostic examination. 9 patients at St. Olavs Hospital and 6 patients at Rikshospitalet OUS were interviewed.
Supervisors: Heidi Gilstad and Berit Brattheim
Operational planning at the orthopedic department.

Marthe Siren Anvik, Mikkel Treu Os and Jon Erik Medhus

We have created a model to schedule order and start time for operations in an operating room over a day. Uncertain items such as duration of operations and arrival of emergency care patients are included in the planning. These items have been thoroughly analyzed through data from completed operations in the department from 2006 to 2016. Here we have considered how factors such as surgery type, orthopedic surgeon and time of day affect the uncertainty. Using mathematics, optimization and data tools, we have tried to find the best timetable. The results are compared to how St. Olav's Hospital does it today.

Determination of operating space, sequence and start time for surgical operations with uncertain duration when doctors work in parallel operating rooms.

Jacob Nyman

Successful planning of surgical operations is essential for effective and safe treatment of patients. By assuming that the main physician only needs to be present during the critical part of the operation (the procedure itself), the doctor may perform operations in parallel in several operating rooms. This allows the doctor to avoid waste of time between operations and utilize more efficiently. We create a mathematical model that sets up a detailed daily schedule for more doctors who perform operations in several operating rooms. The model takes into account that the operating time is uncertain and is based on data from the orthopedic department at St. Olav's Hospital. Based on relevant literature, model results and conversations with personnel from the department, we provide our recommendations for how the department can utilize its operating rooms and employees more efficiently. This includes methods to improve the estimation of the duration of operations, increased awareness during evaluation of planned and completed schedules and benefits and challenges associated with a possible schedule where doctors can perform operations in several operating rooms.
Student Project, DMF, NTNU

Kjetil Tystad Lund
“Electromagnetic Navigation vs. Fluoroscopy in Aortic Endovascular Procedures - a Phantom Study”
The main subject was written the autumn semester 2015 and ended in 2016. Supervisor Frode Manstad-Hulaas and co-supervisor Geir Arne Tangen.
The project investigated the use of electromagnetic navigation compared to traditional fluoroscopy during simulated endovascular instrument navigation. The investigation was carried out at FOR, using a phantom of the abdominal aorta with renal arteries.
The navigation system is combining pre- and/or intraoperative image data sets with electromagnetic position recordings of endovascular instruments. Thereby a 3D real time visualization of the instruments’ position and orientation in the vessel is obtained. By using electromagnetic navigation, the use of intravenous contrast injection is avoided and the total dose of irradiation is reduced.
Five “Operators” with different experience took part in the investigation. A total of 120 cannulations of the renal arteries of the phantom were performed; 60 with each technique. The conclusion is that electromagnetic navigation was of sufficient quality for guiding of endovascular interventions. This technique might be useful in cases with complex anatomy and whenever the dose of contrast material should be minimized.

Bachelor degrees 2016

Biomedical laboratory scientist: 
Microbiological testing of flexible endoscopes used for clinical work at department of pulmonary medicine and ENT, St.Olavs Hospital.
Evaluation of methods for testing of microbiology at departament of pulmonary medicine and department of ENT, St.Olavs Hospital.
Bachelor candidates: Kjersti Schei and Irina Rashid, NTNU.

Department of Radiography:
Iterativ rekonstruktion on lowdose PET CT imageing.
Bachelor candidates: Espen Fjellås, Jonas Grotnes and Sissel Jensen, NTNU.

“Radiation dose to anesthetics and cardiology personel during TAVI”
Bachelor candidates: Amalie Aarseth and Lisa Mari Hatlelid, NTNU.

“Evaluation of irradiation done on urologist at St.Olavs Hospital during the procedures PCNL and RIRS”
Bachelor candidates: Benjamin Midjo Ysland, Åse Marie Oterholm and Karoline Eia Nilsen, NTNU.

Departement of nursing education:
“Entering the sterile area of the operating department”
Bachelor candidates: Kristin Brun-Pedersen and Julie B. Bjørnevaag, NTNU.
Other Projects

An important part of the mandate of The Operating Room of the Future is to develop and promote research and development projects in the intersection between scientists, health care personnel and industry. The aim is to create new and original knowledge with new solutions which are useful for the patients. We are in the intersection between science and innovation – between creation of new knowledge and new solutions and their application in daily clinical practice.

The collaboration with various clinical disciplines is important to make sure those new solutions, methods, processes and new knowledge is introduced in clinical routine. We have our own infrastructure for the testing of new medical technology and new treatment modalities to create and maintain the bridge between new knowledge and well known routine. FOR has an extensive collaboration with national and international industry through research and development projects. This cooperation is important for introduction and use of new knowledge in clinical practice.

By establishing NorMIT the Norwegian Research Council is emphasizing that Operating Room of the Future has methods and systems for effective collaboration with the industry and clinical groups to create and apply new knowledge. The Norwegian Research council as well as EU’s frame programs for research and development is emphasizing that practical application of results of research is becoming an important criterion for success in financing projects. We regard funding of the NorMIT project, which is now well established, as recognition of our focus on innovation. It will also represent an important basis for our strategic commitment in new international research and development projects. In an international perspective we experience great interest in our work and that we are attractive as collaborators within EU’s framework programs for research and development.

Quality register for ENT surgery and “Fast track”

In January 2012 a quality and research register was established for patients who had undergone endoscopic sinus surgery. Quality of life was measured preoperatively and at 6 months postoperatively. All endoscopic and open operations were recorded consecutively.

By the end of 2016, 930 patients are included. The register opens for research, with parameters for the effect of intervention at FOR.

- 2 abstracts at the Annual national scientific meeting for ENT surgery
- 1 scientific article has been submitted
- 1 PhD candidate
- St. Olavs Hospital has been assigned responsibility for the national register for tonsils. Startup nationally 2017

Fast-track in this connection means a standardized course for certain groups of patients who are going to have nose-sinus surgery. It includes teaching of patients, direct booking of appointments and organization of work to obtain a treatment that is effective and cost-effective for the society as a whole.

Sialoscopy-an aid in the diagnosis of tumors of the salivary glands

Sialoscopy is an examination where the ducts of the salivary glands can be inspected by a flexible instrument. This project is investigating the use of this examination in the diagnosis of conditions like concrements, tumors and other diseases of the salivary glands. Currently, St.Olavs Hospital is the only place in Norway to make these minimal invasive procedures, so that we are receiving patients from all over the country. The equipment is used by the department of ENT and oral surgery. In 2017 a quality register will be created.
Balloon sinoplasty for chronic rhinosinusitis
We are testing equipment for balloon dilatation of the orifice of the frontal and maxillary sinus for minimally invasive reestablishment of drainage from the sinuses. The method is used in selected patients where the drainage has been blocked by chronic rhino-sinusitis. So far 20 patients have been included in the investigation. A study on the quality of life after balloon dilatation is running. This work is continuation of the master thesis of Marit Amundsen Furre. Leader of the project: Assistant Professor Vegard Bugten.

TPO-150 investigation. Use of depot-opioid as pre-and postoperative pain medication in primary knee arthroplasty
A double-blind randomized controlled study. Tapentadol vs. Oxycodone vs. placebo
As a FOR project, there is currently a study on the testing of various “pain packages” for patients who get a knee prosthesis. Currently, inclusion and testing, this will probably last until mid 2018. The aim of the study is to develop even better pain management for patients being operated, also for other types of surgery than knee prostheses and for subjects other than orthopedics. Follow-up of patients occurs at home with reporting of effects and symptoms by tablets. The testing of this tool can also benefit other patient groups in the long term. Project Manager Torbjørn Rian, Chief Anesthesiology, Anesthesia Department of St. Olavs Hospital.

Air flow measurements and mapping of turbulence that produces unfortunate air currents
Due to the general increase in hospital infections at St.Olavs Hospital, this project is established under the auspices of the Operation Room at the Future, FOR. The project is measuring airflow in FOR-operating room 8 with operating room 7 as reference; the operating rooms are located in the Orthopedic Operations Department. Both operating rooms have LAF roofs. The tests and measurements will be relevant to other professional environments, both locally and nationally, as there are few results to show. Lamp manufacturers show their own results, but they are often carried out under ideal conditions where lamp hangers and other roofing equipment are custom-made. The measurements will map out exactly how air flows in and under LAF roofs. Will suspended equipment and arms cause turbulence which in turn affects air currents in an unfortunate direction? We will also find out how heat and temperature affect air currents.

"One step back". Radiation Hygiene Project
This project deals with radiation protection for employees working on the use of X-ray equipment in an operating theater. We have acquired a dosimeter system that will increase awareness of the staff in the operating room in terms of radiation protection. The dosimeter system shows on a screen how much radiation the individual gets at exposure and how the movement pattern, distance and time can decrease or increase received radiation dose. There is a great focus on radiation protection at St.Olavs Hospital, but there is a lack of awareness about the subject. There are many occupational groups in an operating room, including anesthesia staff, surgery nurses, surgeons, radiologists, cardiologists, radiographers, etc. Many of these may be exposed to radiation. This project focuses on radiation protection for ALL who are located near X-ray equipment in an operating theater.
By increasing awareness of the individual’s movement pattern and visually showing how their behavior affects radiation, they can learn how they can avoid radiation hazards and provide radiation awareness.

Raysafe i2, «like a canari in a colemine»
Photo: Liv-Inger Stenstad, FOR
**Test project «Stroboscopy- Laryngoscopy»**
The trial period was conducted by the Operating Room of the Future, following requests from the clinics. The relevant equipment suppliers were Karl Storz, Olympus and Pentax. The test project took place between 01.11.15 and 24.11.16. Essentially two doctors have tested the new technology during the trial period. As far as the team around the patient is concerned, it has largely been constant. A total of 60 procedures were conducted - 20 patients Karl Storz, 20 patients Olympus and 20 patients Pentax. After completion of the trial, FOR made a final report, which was submitted to the Clinic Manager at the Clinic for ENT, Oral surgery and Eye diseases.

The test project contributed to a requirement specification that led to an acquisition of equipment. The operating room of the future thanks for the mission and the good cooperation during the trial period!

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**The Visualization project at the Neurosurgical Department**
The Operating Room of the Future at St. Olav's Hospital, University of Trondheim, Norway has implemented a first test case for using 4K image acquisition and visualization in neurosurgery during the removal of brain tumors and aneurysms. The images were captured live from the optical microscope using an optical splitter and from the intra-operative navigation unit and displayed on an 85-inch 4K display or CLEDIS panel from Sony.

The resulting image quality is impressive and the higher resolution provides a better visual understanding of the surgical field. Image interpretation becomes easier on the larger display. This provides better outcome for the patient and improves the result of the surgical procedure. The tumor and its borders are visualized clearly.

Main advantages:
- 4K/CLEDIS provides excellent depth of field
- 4K/CLEDIS gives good depth understanding
- Large display provides better picture understanding
- Improved visualization of tissue structures
- Better ergonomics by displaying all the information on the same display
- Better outcome and safety for patients
Scientific articles

Ekroll, Ingvild Kinn; Avdal, Jørgen; Swillens, Abigail Emily; Torp, Hans; Løvstakken, Lasse.  
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Combined 2-D vector and tracking Doppler imaging for improved blood velocity quantification.  
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Fadnes, Solveig; Nyrnes, Siri Ann; Wigen, Morten Smedsrud; Tegnander, Eva; Løvstakken, Lasse.  
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Proceedings - IEEE Ultrasonics Symposium 2016; Volum 2016-November. NTNU

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Amundsen T, Sørhaug S, Leira HO, Tyvold SS, Langø T, Hammer T, Manstad-Hulaaas F, Mattsson E.  
A new removable airway stent.  

Sagberg LM, Drewes C, Jakola AS, Solheim O.  
Accuracy of operating neurosurgeons’ prediction of functional levels after intracranial tumor surgery.  

Unsgård G, Rao V, Solheim O, Lindseth F.  
Clinical experience with navigated 3D ultrasound angiography (power Doppler) in microsurgical treatment of brain arteriovenous malformations.  

Drewes C, Sagberg LM, Jakola AS, Solheim O.  
Quality of life in patients with intracranial tumors: does tumor laterality matter?  

Selbekk T, Solheim O, Unsgård G.  
Ultrasound-guided neurosurgery: experiences from 20 years of cross-disciplinary research in Trondheim, Norway.  
Neurosurg Focus. 2016 Mar;40(3):E2. PMID: 26926060

O. Solheim.  
Is aneurysm surgery too exciting for our own good?  


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Kathpalia, Aditi; Karabiyik, Yücel; Eik-Nes, Sturla; Tegnander, Eva; Ekroll, Ingvild Kinn; Kiss, Gabriel; Torp, Hans Garman. Adaptive Spectral Envelope Estimation for Doppler Ultrasound. IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control 2016 ;Volum 63.(11) s. 1825-1838

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Bugten, Vegard; Nilsen, Ann Helen; Thorstensen, Wenche Moe; Moxness, Mads Henrik Strand; Amundsen, Marit Furre; Nordgård, Ståle. Quality of life and symptoms before and after nasal septoplasty compared with healthy individuals. BMC Ear, Nose and Throat Disorders 2016 ;Volum 16.(1) s. 1-7 NTNU STO

Publikasjoner fra Intervensjonscenter IVS – NorMIT: Se deres egen årsmelding – https://oslo-universitetssykehus.no/avdelinger/akuttklinikken/intervensjonscenteret

Book chapter


Poster

Lectures

Individual lectures/ presentations at conference


08.01.16 | Electrosurgery. EMU course for orthopaedic surgeons. Jan Gunnar Skogås. | 25.05.16 | Presentation at the National network for internet-based teaching under the direction of Health Authorities of Central Norway. Operating Room of the Future. New treatment modalities and innovative medical technology. Jan Gunnar Skogås.


20.01.16 | National Forum for Top Leaders,NTP,Oslo. How is medical technology and new treatment modalities influencing the hospital? And which challenges are therefore faced by the hospital administration? With background from The Operating Room of the Future. Jan Gunnar Skogås | 09.06.16 | Research seminar. The Intervention Center, UiO- 20 year anniversary. Fortress of Akershus. FOR-NorMIT and cooperation between FOR and The University of Oslo. Jan Gunnar Skogås.


14.10.16 | The hospital partner HSØ. Gardermoen Clarion, the Qube. Medical technology leading to new treatment modalities, FOR-NorMIT. Jan Gunnar Skogås.
FOR-related lectures

Haavik T
Representasjonsteknologi, samhandling og sikkerhet i kirurgi. FOR Fagseminar 2016.

Realistic organ phantom with flow for multimodal image-guided liver therapy research and training. Presentation at the 28th Conference of the international Society for Medical Innovation and Technology (iSMIT), Delft, The Netherlands, 5-8 October 2016. 1st Technology Award at the closing ceremony of the conference.

Intraoperative fluorescence imaging during laparoscopic pancreaticoduodenectomy and single-site distal pancreatectomy. Presentation at the 28th Conference of the international Society for Medical Innovation and Technology (iSMIT), Delft, The Netherlands, 5-8 October 2016.

Open source platform for ultrasound-based navigation in laparoscopic pancreaticodudodenectomy and single-site distal pancreatectomy. Presentation at the 28th Conference of the international Society for Medical Innovation and Technology (iSMIT), Delft, The Netherlands, 5-8 October 2016.

Langø T et al.
Imaging and image-guided minimally invasive interventions in the future operating room - Technological and clinical teams in close collaboration for 20 years. Invited Keynote talk at the 28th Conference of the international Society for Medical Innovation and Technology (iSMIT), Delft, The Netherlands, 5-8 October 2016.

Using the CustusX toolkit to create an image guided bronchoscopy application: Fraxinus. Poster presentation at IPCAI/CARS, June 21-25, Heidelberg, Germany.

Håkon Olav Leira.

Håkon Olav Leira.
Live transmission FOR

- Masterstudents April 13th. Obesity operations from the FOR operating room at Gastro
- HEMIT Conference September 22, 2016

In conjunction with “8th International Training Course - 3D Ultrasound and Neuronavigation» 14-15. June - arranged by the Competence Center for Ultrasound and Image guided Therapy Treatment at St.Olavs Hospital, NTNU and SINTEF - Successful live transfers were conducted from the FOR- operating room down to the NA Auditorium both days. Both Geirmund Unsgård and Ole Solheim had interactive sessions with the participants on the course.

Here is a picture from the transfer where the clinic manager Geirmund Unsgård at the living room presents the current surgical plan for the participants present in the NA auditorium.

Live transfer of operation from the FOR-operating room to the auditorium in connection with this year’s international course in ultrasound-related neurosurgery.
Photo: Gabriel Kiss, FOR
FOR in the media

VG TV: http://www.vgtv.no/#!/video/134712/ny-metode-kan-redde-liv

YouTube: https://www.youtube.com/watch?v=QqwlK0y94kU

Youku: = Youtube på kinesisk
http://v.youku.com/v_show/id_XMTg0NDU1NTM5Ng= =.html?

NRK radio P1 / Norgesglasset 12.12.2016 “En stent er et viktig hjelpemiddel i medisinen, men hvordan kan en raggsokk ha vært med på å revolusjonere den?”
https://radio.nrk.no/serie/norgesglasset/DMPA010246
16/12-2016#t=28m31s

Gemini: “Vil redde liv med gratis teknologi.”
http://gemini.no/2016/05/vil-redde-liv-med-gratis-teknologi/


A new removable airway stent, Facebook (Norsk, samt Engelsk, Tysk, Spansk etc) https://nb.no.facebook.com/NTNUmedicine/posts/10154647647295370 (> 100 000 treff første uker)

Dagens Medisin: “Norskutviklet verktøy forbedrer diagnostikk av lungekreft.”
https://www.dagensmedisin.no/artikler/2016/05/31/norskutviklet-verktøy-forbedrer-diagnostikk-av-lungekreft/

Adressa: “Ny oppfinnelse kan spare kreftpasienter for åpen kirurgi.”
http://www.adressa.no/nyheter/trondheim/2016/12/06/Ny-oppfinnelse-kan-spare-kreftpasienter-for-%C3%A5pen-kirurgi-13889427.ece

Knitted removable airway stent, Medtronic – Eureka (Innovation articles) Nov 2016:
http://www.medroniceureka.com/innovation-articles/inspiration/knittedstent

Radiointervju: NRK Trøndelag.
Forskerdate: Hanne Sorger. Navigert ultralyd i lungene

Gemini (Internett): «Bruker matematikk mot savnnapné» Dragland, Åse Kirsti; Johnsen, Sverre Gullikstad; Moxness, Mads Henrik Strand.
2016-10-04 NTNU SINTEF