INTRODUCTION
The need for change in health care
The need for improved health care services and new models of care is imminent. The population on average lives longer, survives previously deadly diseases, and is increasingly challenged by life-style related diseases. The disease burden is changing from acute to chronic diseases. Presently, 60% of all deaths are due to chronic diseases according to a WHO global report. The time an average hospital patient spends in a hospital bed drops, and hospital medical treatment are increasingly done in day care. After e.g. a minimally invasive surgical procedure, the patients are transferred to a care home or their own home as soon as they are stable. A worrying trend is that re-hospitalization is increasing; numbers from Norwegian healthcare statistics indicate that 10% of discharged patients are re-hospitalized within a month. This is costly for the society and stressful to the patient.

New technology and new models of care make it possible to counteract the negative trends. Advanced sensor systems, broadband communication and service-based information systems are active research areas, and are being tested all around the world, showing good potential in providing better quality of care with higher efficiency.

Sensors and instrumentation presently accounts for at least half the manufacturing cost in cars. Advanced sensor systems monitor engine status, safety systems, and passenger comfort. In many cases, the instrumentation can even forward the status to the service station. We foresee an analogy in health care in the near future.

Health care services for outside hospital settings
The hospital sector offers highly efficient care using sophisticated diagnostic equipment and treatment remedies. However, the patient is
increasingly found in out-of hospital settings. For a patient recuperating after surgery, closer follow-up and monitoring over a limited period of time can contribute to a safer recovery phase and early detection of cases where further hospital treatment turn out to be needed. Elderly or chronically ill patients can benefit from closer monitoring that can enable long-term trend analysis guiding both diagnostic and therapy processes.

Several other outside-hospital groups would benefit from preventive specialist intervention and follow-up, such as emergency casualties and high risk workers; e.g. soldiers, firemen... Emergency casualties need robust, general, “one fits all” solutions that can capture medical vital signs in chaotic field scenarios, aiding field personnel in assessing the injuries and giving early warning to hospital personnel for required operations. High risk workers need physiological monitoring solutions to continually assess his/hers health risks in the work scenario at hand.

"People save people. Information technology can only improve the chances of doing that better."
- Ilias Iakovidis (Deputy Head, ICT for Health, European Commission)

New models of care: a way to proceed
New models of care will enable care provision in new situations and places. It will change the daily life of the stakeholders involved, and pose new requirements on technology:

- The patient must take a more active stance in own healthcare provision
- Caregivers must adapt to new routines for remote follow-up of the patients, and increased patient contact via patient web-pages, e-mail and tele-/video conferencing.
- Sensors must be non-intrusive, reliable, and provide an easy-to-use interface for integration with communication systems.
- Information systems must be flexible, interoperable and conform to national or preferably international standards.
- Sensor data interpretation models that combine patient data from different sources, must be developed and incorporated into tools for efficient decision support and patterns of care.
Health organizations must rethink the way people work together and how technology is utilized in the care process, without losing the human perspective of providing care.

Elements of modern healthcare services. The four elements CARE – CAPTURE – SHARE – UNDERSTAND are elaborated in subsequent sections.

Our vision for future health care is improved quality of care AND increased care efficiency, allowing more patients to be treated at lower cost to meet the emerging demands of the population.

This paper explores this vision and describes some R&D challenges that have to be addressed in near future in order to see it happen. Examples of current state-of-art and directions for R&D are taken from SINTEF’s research portfolio.

CARE: Enabling new models of care with new technology

New technology makes it possible to perform advanced patient treatment, monitoring and follow-up procedures outside hospitals. This has implications on the way health care is organized and how information and communication technology is utilized, resulting in new models of care.
Teamwork treatment is a new model for personalizing and managing care for patients. This type of model requires a multidisciplinary and flexible information system (e.g. individual plan with role-based access control) and efficient communication systems for patient-patient and patient-caregiver management. To gain the full effect of these models, sensor systems within the patient’s home (domotic) and sensor systems for measuring the patient’s physiological parameters systems play an important role by improving patient safety and provide a basis for decision support.

The new solutions empower the patient (and close family) to have a more active role in own healthcare provision. The patient must take responsibility for following up on medication and other treatment and must have an active dialogue with the treatment team. Patients must accept the technology as being a part of their everyday life. This requirement is well matched by the increase in IT competence levels of the general public. We are getting older, but at the same time we are also getting increasingly familiar with using the information and communication technologies as part of our everyday lives.

New models of care also impose changes on how healthcare organizations organize their work. New routines must be developed that allow for new ways of interaction and increased collaboration, not only between the different care givers, but between care givers and patient. A main challenge is to generate patterns of care that optimizes patient-care giver interaction, A pattern of care is in essence a plan or decision support for effective care; including what activities that are to be performed, what roles are involved (e.g physicians, family), what type of monitoring is executed, and what information systems are used and in what way. Identifying good patterns of care will be the logical core of a patient-centric care process.

With the increased involvement of the patient and his or her family to follow the prescribed pattern of care follows a need to develop treatment and monitoring equipment that are adapted to the patient. It is an unfortunate fact that many current systems have been developed because technology allowed it. Rather than a technology push, user driven product development methodologies are needed. Systems will have a much better chance of gaining user acceptance and the intended usage pattern if they conform with key user requirements, such as usability, trustability, usage comfort, and
maintenance. It is also important that the system convey an understanding that it is contributing to better health care for the patient.

In 2015, we expect that physiological monitoring and other safety systems will be a demand component in the work outfit for individuals working in hostile environments.

**PROTECTION AND IMPROVED COMFORT FOR THE HIGH RISK WORKER:**
Helly Hansen SeaAir Helicopter Transport Suit for Petroleum Workers.

Transportation to and from Norwegian offshore oil-fields takes place using helicopters. Survival suits are worn continuously during transport in hot helicopter cabins, yet they should keep the workers from either drowning or freezing to death in the event of a helicopter crash-landing at sea. Based on thorough requirements analysis involving the petroleum worker’s associations, new standards were established, stating that the suits should be more comfortable to wear during regular transport, while maintaining safety in an emergency landing.

SINTEF recently developed the SeaAir helicopter transport suit for Helly Hansen. It is the result of a comprehensive and systematic design process based on knowledge of how heat and cold affect the human body, and how smart textiles can work in the same direction as the body’s own reaction to cooling and heating. Careful laboratory evaluation has demonstrated the heat regulating properties of the phase change materials included in the new suit. The suit is also equipped with a radio-based location system m. The suit instantly became the dominating product, and was Nominee for the Honorary Price of Product Design in Norway 2008.

**CAPTURE: Patient sensor systems**

It is a general trend that the number of information sources providing patient information is increasing. Sensor systems can be defined as any means to capture information about the patient. It can therefore include anything from sensors in the home/surroundings, voice, identity, location systems, medical imaging systems, to the more obvious sensors measuring the patient’s medical parameters.

It is an important research challenge to effectively extract health information from various sources of the mobile patient, and combining them with the clinical knowledge from medical consultations and hospital visits. Sensor systems of today are usually based on sensors operating individually without a common sensor platform, and can not easily share sensor information. Technologies for wired or wireless merging of information in local area or body area networks are important in this respect. Likewise, sensor solutions that combine several measurement parameters into a single, multi-parameter sensor device are attractive.
Ease-of-use is essential when medical expert systems should be operated and maintained by the mobile patient. Systems must be reliable, fail-safe and have advanced error detection built in. Systems for continuous monitoring carried by the patient are in particular challenging. These include both in vivo (inside the body) sensors and sensors worn on the skin. In contrast to bed side monitoring, mobile patients are moving, thereby requiring sensors concepts that are robust against artifacts introduced by movements. An implanted sensor or a sensor placed directly on the patient’s skin also introduces substantial biocompatibility issues.

Miniaturization is crucial in order to make it minimally obtrusive and long lasting using minimum power and requiring a minimum of maintenance. In this respect, the mobile patient demands to the latest in sensor and electronics miniaturization technology.

---

**HEARING PROTECTION AND COMMUNICATOR FOR THE HIGH RISK WORKER: Nacre’s QUIETPRO**

Nacre's QUIETPRO is a digital, lightweight communication system with automatic and adaptive hearing protection. It can suppress noise, yet allow speech and other information pass through. It is developed within SINTEF and spun off to a new company Nacre AS, which was acquired by Bacou-Dalloz for 120 mill USD in 2007. The present product QUITEPRO www.nacre.com is mainly intended for military applications, and the US Marines have placed orders of approximately 60 mill USD to the company.

The ear is an interesting platform for more than hearing. Voice recognition, location sensors, integrated physiological sensors are some of the options for expansions of this technology.

Sensor solutions that combine several measurement parameters into a single, multi-parameter sensor device are attractive.
DEVELOPMENTS IN MINIATURIZATION TECHNOLOGY OFFERS NEW OPPORTUNITIES TO MEDICAL SENSORS

LAB-ON-A-CHIP DIAGNOSTICS
SINTEF has an extensive research activity on the development of disposable lab-on-a-chip cartridges for disease diagnosis. The MicroActive project (www.sintef.no/microactive) has developed an instrument for molecular diagnostics intended for use in the doctors’ office. The instrument will first be used for patient screening for a group of viruses causing cervical cancer. Microfluidics and biotechnology form the basis for the development. Other related projects are MicroBuilder, infrastructure for microfluidic devices (www.sintef.no/microbuilder) and SmartHEALTH, development of new lab-on-a-chip biosensor concepts for cancer detection (www.smarthealth.com).

A ROBOT YOU CAN SWALLOW:
The VECTOR project aims at investigating and developing a miniaturized robotic pill for advanced diagnostics and therapy in the human digestive tract. SINTEF Research: Miniaturized ultrasound devices, navigation and visualisation technology. www.vector-project.com

IS THE AIR I BREATH CLEAN?
Diffractive optical elements realized in silicon or polymer technology has been developed within SINTEF. This technology can dramatically reduce the size of sensors employing optical spectroscopy. http://www.sintef.no/content/page1__1192.aspx

The sensor systems will also typically have a short range wireless connection to e.g. a PDA, SmartPhone or cell phone that can forward information into the health care information system. Standards based protocols like Bluetooth and ZigBee are currently used, but there are still major challenges related to establishing the right connections, maintaining safety and security and operating at sufficiently low power consumption.

Many patients need regular hospital visits as part of their therapy, monitoring the progress of their illness. The hospitals are therefore an important component in the “chain of care”. In this case, their home based monitoring equipment should also work in hospital environments. Likewise, the hospital internal monitoring can benefit substantially from new and improved monitoring systems that can follow the patient from the ambulance or hospital reception, through the hospital care, and into the convalescence phase. It is therefore crucial to maintain a close link with the medical experts in the development of out-of-hospital health care systems.

Hospitals is and will always be a central entity in the chain of care for large patient groups.
SHARE: Simpler  sharing with service based information systems

A prerequisite for improved quality of care is ensuring easy access for the different care givers to updated patient information at the right time and place. The care process for e.g. a chronically ill person involves a whole range of care-givers, ranging from the GP, to specialists at hospital to home care personnel, whose non-trivial job it is to administer accurately the care (e.g. medication) specified by one of the other parties. For each care-giver, there is, typically, a information system involved. The required sharing of patient information between the central care stakeholders is hampered by lacking interoperability of the various systems, due to proprietary solutions and non-standard interfaces.

Traditional solutions for information sharing between personnel accessing different legacy systems are often based on some form of integration. New approaches that focus on interoperability rather than integration are now gaining ground. Service Oriented Architectures (SOA) offers a way forward towards increased inter-operability between legacy information systems. The idea is to leave the systems as is, but allow the different system capabilities to be selected and provided as services that can be made available to the community of care at large. As new sensor-based services are developed, a true service oriented architecture can integrate these services without total re-engineering of existing systems, keeping cost and risk of deployment at a manageable level.

NEW APPROACHES TO ECORELAYS RELIEVING THE PRESSURE ON SECONDARY CARE SERVICES

Ambulatory ECG (Holter) examinations are carried out to diagnose heart arrhythmias. Patients at risk, having received a referral from their doctor, travel often long distances to the hospital to get Holter-equipment attached to the body, only to return to the hospital the next day after the prescribed 24 hour monitoring period to deliver the equipment for analysis.

SINTEF will investigate how new collaboration processes and new technology solutions can improve care efficiency and relieve secondary care services from some of their tasks, by moving the initial Holter examination to the offices of primary care doctors. Automatic ECG data analysis and computer supported collaboration tools enables the filtering out of no-risk patients at primary care level and an overall higher volume of Holter examinations.
Whereas new approaches like Service Oriented Architecture addresses the problems of lacking interoperability between existing legacy systems, model driven development ensures that new health informatics systems are developed for optimal quality and manageable use of resources. A whole family of methodologies are emerging (e.g. Model Driven Architecture and Model Driven Software Development) based on the same core idea: they are vendor-neutral approaches that document the business functionality of a service independent of the technology that implements them. This opens up for models being used directly in the implementation process, reducing complexity and enabling re-use of the models on different technological platforms.

Trust is a major factor when it comes to successful deployment of ICT. Stakeholders involved must be sure that the information systems and communication solutions are secure, protecting data integrity and confidentiality. Patient privacy is essential in this respect. National regulations developed to protect the individual rights to privacy for sensitive health information are necessary fence-posts to ensure that emerging technology for monitoring and information sharing is not misused.
UNDERSTAND: Interpretation models for improved decision support

A typical care process consists of many contact points between patient and care personnel, each capturing new patient data that leads to an enhanced understanding of the patients needs for care and an adaptation of the treatment.

In most cases, there is not an one-to-one relation between an illness and a physiological parameter. On the contrary, in most cases information about several parameters are needed in order to extract higher order information. For example in the treatment of diabetes II, it is not sufficient to worry about the glucose level. Additional factors such as blood pressure, obesity, activity level and other medication taken contribute substantially to patient’s condition. Treatments only addressing the glucose level therefore might give unwanted side effects.

If you ask a cardiologist how many ECG leads (electrodes) are needed to monitor a patient, he or she would probably answer: 10. During surgery and in intensive care, usually only 3 leads are used to monitor the heart rate. If you want to know if a patient has been out of bed or walked to the shop today, a simple accelerometer or a location sensor might suffice.

The complexity of the technical solution must be adapted to the usage scenario and information need at hand!

Patients constrained to a hospital bed and under surveillance by trained personnel can be monitored quite well. The mobile patient, on the other hand, operates monitoring equipment at his or hers own will, with limited training, and under a much wider range of contexts than the hospital bed patient. Effective methods to extract health information from various sources of the mobile patient, understanding the patient’s conditions and surroundings, and combining them with the clinical knowledge from medical consultations and hospital visits are key challenges.
The main purpose of the monitoring is to provide decision support for the patient and care giver. It must be based on a thorough understanding of the user patterns of the different mobile patients. Decision support must also be reliable, that is, have prediction power to identify situations that require interventions, while not causing numerous false alarms. Means to effectively resolve unclear issues, for example by using location information and/or voice or text communication patient between patient and care giver will also be helpful.

Data synthesization, multi-parameter analysis and sensor interpretation models that merge different sensor data to get overall indications of patient status are needed. Demonstrators and products for continuous vital signs monitoring are emerging, but systems that merge all the assembled information to obtain higher order health information are lacking. We find that a substantial research effort is needed in this area.

Physiological sensors combined with portable handheld technology allow continuous or on-demand readings of health parameters. In a US Congress funded, US-Norway collaboration program called ESUMS, SINTEF develops a vital signs monitoring system providing improve the physical rehabilitation process of congestive heart failure patients. The system monitors a wide range of parameters, and forwards aggregate data to an internet accessible monitoring unit using cell phone technology. Sensors include heart rate, respiration rate, activity, posture and skin temperature and they have been designed to be robust and reliable for mobile users.
CONCLUDING REMARKS

The example projects presented in this paper are the results of fruitful collaborations with competent partners that share our vision “Technology for a better society”. We welcome you to join forces with us and collaborate in projects addressing the research and development tasks that are still ahead.
FACTS ABOUT SINTEF

The SINTEF Group is the largest independent research organisation in Scandinavia. Every year, SINTEF supports the development of 2000 or so Norwegian and overseas companies via our research and development activity.

Business concept
SINTEF’s goal is to contribute to wealth creation and to the sound and sustainable development of society. We generate new knowledge and solutions for our customers, based on research and development in technology, the natural sciences, medicine and the social sciences.

Vision
Technology for a better society.

Our services
We solve our customers’ problems through research contracts in the following fields: Health, information and communications technology, marine activities, materials science and applied chemistry, petroleum and energy, technology management and building/construction. SINTEF intends in this way to act as a driving force in the process of restructuring and developing Norwegian society.

In order to ensure that this research is available to society as a whole, we also operate units whose principal activity is consulting. We are also active in testing and certification in a number of areas, not only within the SINTEF Group itself, but also through companies in which we are shareholders and via cooperation with other organisations. These activities make significant contributions to creating added value from the knowledge and solutions produced by our researchers.

We wish to be of use to both small and large companies in our markets. For example, we can help a small-scale gravel producer analyse a rock sample, at the same time as our researchers are playing an important role in developing the next generation of solutions to the problem of energy supply.

By working on a wide range of projects, we are helping to realise our own vision, that of technology for a better society.

Locations
SINTEF has approximately 2000 employees, 1500 of which are located in Trondheim and 500 in Oslo. We have offices in Bergen, Stavanger and Ålesund, in addition to offices in Houston, Texas (USA), Skopje (the former Yugoslav Republic of Macedonia), Warsaw and Cracow (Poland), and a laboratory in Hirtshals (Denmark). SINTEF’s head office is in Trondheim.
## Examples of Recent/On-Going Medical Technology Research Projects and Activities in SINTEF

### Medical Robotics

**VECTOR: Versatile Endoscopic Capsule for gastrointestinal TumOr Recognition and therapy.** EU project aiming at developing a miniaturized robotic pill for advanced diagnostics and therapy in the human digestive tract. SINTEF Research: Miniaturized ultrasound devices, navigation and visualisation technology. [www.vector-project.com](http://www.vector-project.com)

### Medical Imaging Technologies

**NAVIGATION INSIDE THE BODY GIVES IMPROVED TREATMENT**

National Center of Competence in 3D Ultrasound develops new methods for minimally invasive therapy. SINTEF collaborates with St Olavs Hospital, NTNU and others, i.e. IGSTK (USA) in development of tools for navigation inside the body based on multimodal imaging. Interdisciplinary technological and clinical research for improved patient care in various applications (i.e. neurosurgery, laparoscopy, vascular surgery). [http://www.sintef.no/upload/Helse/Center_3D_Ultrasound_Trondheim.pdf](http://www.sintef.no/upload/Helse/Center_3D_Ultrasound_Trondheim.pdf)

**ULTRASOUND and MR IMAGING FOR IMPROVED HEALTH CARE**

MILab is a 8 year research program with a budget of 57 mill US$ funded by The Research council of Norway, Norwegian enterprises, NTNU, St Olavs Hospital and SINTEF with the objective to facilitate cost efficient health care and improved patient outcome through innovation in medical imaging. Projects are in advanced ultrasound and MR imaging, display, multimodality, transducer technologies, image guided surgery, registration of images, navigation technologies.

The operating room of the future at St.Olavs Hospital. Development and innovation of new technology based on user demands in a controlled and interdisciplinary research environment is important for successful product deliveries.

Particle and x-ray detectors in silicon technology. [http://www.sintef.no/content/page1____4020.aspx](http://www.sintef.no/content/page1____4020.aspx)

### Simulation and Training Technology

**TRAINING AND SIMULATION IMPROVE QUALITY**

Together with Laerdal Medical, SINTEF develops simulators for improving the skills and competence of users of ultrasound in and outside hospital. Simulators for FAST examinations of trauma patients is one of many applications.

### Neuroscience

**Child abuse: Shaken baby syndrome.**

In collaboration with the Norwegian National Forensic Institute, SINTEF is carrying out research on the mechanisms and forces children are exposed to. [http://www.apollon.uio.no/vis/art/2007_4/Artikler/infant_brain](http://www.apollon.uio.no/vis/art/2007_4/Artikler/infant_brain)

### Nano-Medicine and Biomaterials

**Lab-on-a-chip diagnostics.** SINTEF has an extensive research activity on the development of disposable lab-on-a-chip cartridges for disease diagnosis. This covers development of microfluidic devices, biochemical reagents and instruments for reading out the process results. SINTEF leads EU projects Microactive (Cervical Cancer detection - [www.sintef.no/microactive](http://www.sintef.no/microactive)), MicroBuilder (infrastructure for microfluidic devices - [www.sintef.no/microbuilder](http://www.sintef.no/microbuilder)) and is a member of SmartHEALTH (development of new lab-on-a-chip biosensor concepts for cancer detection - [www.smarthealthip.com](http://www.smarthealthip.com)).
HEALTH INFORMATION TECHNOLOGIES

In the EU project mPower, SINTEF collaborates with universities, business partners and health care organizations within the EU to develop service specifications and middleware components that can conform to standards and can be re-used. The objective is to shorten time to market for new standards-based and innovative services for elderly and cognitively disabled people. [www.mpower-project.eu](http://www.mpower-project.eu)

**User needs as a starting point for innovation.**

Need-driven innovation involves understanding consumers' current and predicting future needs, in order to be able to develop solutions based on real needs. Innovative activities are thus based on an in-depth understanding of user needs, before they are followed up with technological and market activities.

In order to raise the level of expertise in the field of need-driven innovation in the health sector, the Directorate of Health and SINTEF Technology and Society have established a five-year strategic cooperation. This cooperative effort will develop and test methods concerned with how best to innovate within the health sector. The aim of the joint effort is thus to strengthen public-sector research and development in the health sector.

**EU project: Integrated Access Control for Health Care Information Systems**

Health care information about a patient is usually scattered among several clinical systems. Health care personnel needs access to all relevant information, and thus system and information integration is currently one of the key issues in health care. iAccess has developed a model for integrated access control for health care information systems, enabling more efficient and secure information dissemination in future health care services.

**Evacuation support system for improved medical documentation and information flow in the military medical evacuation chain.**

The EvacSys prototype system, deploying electronic patient information tags and handheld terminals for field use, was developed and evaluated as part of a Memorandum of Understanding between the Department of Defense (USA) and the Ministry of Defense (Norway), with close cooperation with the Norwegian Joint Medical Service, the Medical Battalion in the 6th Division of the Norwegian Armed Forces, and the Telemedicine and Advanced Research Center/US Army Medical Research and Material Command (TATRC/USAMRMC). S. Walderhaug et al., Evacuation support system for improved medical documentation and information flow in the field, Int. J. Med. Inform. (2007), doi:10.1016/j.ijmedinf.2007.01.006

ADVANCED PROSTHETICS AND HUMAN PERFORMANCE

**Work physiology laboratory.** SINTEF has an accredited, complete work physiological laboratory for performance measurements of body temperature, metabolism, cardiac and pulmonary function. It includes pool for flotation and thermal protection properties, and climatic chambers for physiological evaluation in high/low temperature stress conditions. Recently, a new non-invasive device for measuring heat and cold stress in firefighters has been validated. [http://www.sintef.no/content/page3__357.aspx](http://www.sintef.no/content/page3__357.aspx)

**SmartWear** is one of six SINTEF areas of special effort. The aim is to develop new technology for smart clothing integrating instrumentation, i.e. clothing with built-in sensors and communication equipment and new multifunctional materials. Project involves leading Norwegian and European textile manufacturers and end users, and is particularly devoted to the challenges of operating in cold climate environments. [http://www.sintef.no/content/page1__12825.aspx](http://www.sintef.no/content/page1__12825.aspx)

BIOMONITORING TECHNOLOGIES

**Medicom Sustained Use Monitoring System (SUMS) demonstrator.** Demonstrator development of a multisensor physiological monitoring system for soldiers in training and military operations. Includes monitoring of heart rate, respiration rate, activity, body posture, temperature and blood oxygen saturation. The system includes a cell phone based data link to an internet accessible data base. Developed in a US-Norway collaboration program on telemedicine.

**Wireless healthcare** – a national network coordinated by SINTEF. The objective is to identify emerging research needs in order to improve health care services. Three main focus areas where emerging wireless technology can be valuable have been defined; patient monitoring in a hospital setting, personal health care for the chronically ill, and home care for the elderly. [www.sintef.no/tradispasient](http://www.sintef.no/tradispasient)
**Need- and user-driven innovation.** User-involvement together with knowledge and understanding of the environment are key factors for successful product development. Knowledge of high risk work-places together with competence in design and product development processes, enables us to develop products that provide improved occupational performance, safety and health. We have recognized a lack of relevant methods for innovation of new products for the health care sector. Since 2007 SINTEF has been engaged in development of improved methods for innovation of products and procedures for diagnostics, health care and preventive health care. The research is performed on behalf of the Norwegian Ministry of Health and Nordic Innovation Centre.

### RESEARCH INFRASTRUCTURE

**Microsystems and Nanotechnology – MiNaLab.** MiNaLab was inaugurated in 2004 and consists of state-of-the-art clean room facilities for micro and nanotechnology. SINTEF operates a complete silicon processing line for development and small scale production of solid state radiation detectors and micro electro-mechanical systems (MEMS). The University of Oslo has it's micro/nano-technology laboratory co-located. [http://www.sintef.no/content/page3_____347.aspx](http://www.sintef.no/content/page3_____347.aspx)

**Design of application specific integrated circuits (ASIC).** Development of analog and mixed signal ASICs designs of high temperature integrated circuits, biomedical sensing systems, precision electronics signal processors for ultrasonic imaging, and signal processing for radiation hard environments. [http://www.sintef.no/content/page1_____18424.aspx](http://www.sintef.no/content/page1_____18424.aspx)

**Communication technology.** SINTEF was in the 1980's involved in the development of the GSM cell phone standard, and has later contributed to the development of standards for high definition digital broadcasting. SINTEF carries out research and development within most of the areas of communication systems. Our field of competence covers most of the areas from system architecture to design and implementation of prototype systems within the fields network technology, wired communication, embedded systems, antenna and RF technology, radar, mixed signal ASIC and wireless communication. [http://www.sintef.no/content/page3_____346.aspx](http://www.sintef.no/content/page3_____346.aspx)

**RF-ID Innovation Centre.** SINTEF and partners have formed a lab and innovation centre for the use of emerging RF ID (radio frequency identification) technology. This technology finds wide application in tracing of merchandise, animals and humans, and will also provide the foundation for substantially more efficient security and control systems. The public sector will change, most significantly the health sector. [http://www.rfidlab.no/](http://www.rfidlab.no/)

### CONTACT DETAILS FOR AUTHORS

**Frode STRISLAND**  
Frod.Strisland@SINTEF.no  
Phone: +47 22067360  
SINTEF ICT  
OSLO, NORWAY

**Ingrid SVAGÅRD**  
Ingrid.Svagard@SINTEF.no  
Phone: +47 22067968  
SINTEF ICT  
OSLO, NORWAY

[www.sintef.no](http://www.sintef.no)