Advanced sensors and detectors

- Research leaders involved
- Capability needs identified
- Research area descriptions
  - Ongoing projects
  - Some research highlights from 2009
- Future funding possibilities
- Collaboration and cross disciplinary possibilities
- Established end user and industrial contacts
# Research leaders

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<tr>
<th>Name</th>
<th>Affiliation</th>
<th>Expertise</th>
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<tr>
<td>Ass. Prof. Mats Eriksson</td>
<td>LiU-IFM</td>
<td>Chemical sensors</td>
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<tr>
<td>Prof. Staffan Rudner</td>
<td>FOI/Chalmers</td>
<td>Security radar</td>
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<tr>
<td>Prof. Bo Liedberg</td>
<td>LiU-IFM</td>
<td>Chemical substance detection</td>
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<tr>
<td>Prof. Atila Alvandpour</td>
<td>LiU-ISY</td>
<td>Electronics, IR-sensors</td>
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<tr>
<td>Prof. Magnus Berggren</td>
<td>LiU-ITN</td>
<td>Single use detectors</td>
</tr>
<tr>
<td>Prof. Eva Lund</td>
<td>LiU-IMH</td>
<td>Radiometric dosimetry</td>
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<tr>
<td>Prof. Anita Lloyd Spetz</td>
<td>LiU-IFM</td>
<td>Explosives detection sensors</td>
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<tr>
<td>Prof. Jan Stake</td>
<td>Chalmers MC2</td>
<td>THz electronics</td>
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<tr>
<td>Dr. Ove Steinvall</td>
<td>FOI</td>
<td>Laser &amp; BC detection</td>
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<tr>
<td>Prof Lars Ulander</td>
<td>FOI/Chalmers</td>
<td>Radar signal processing</td>
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<tr>
<td>Dr. Henric Östmark</td>
<td>FOI</td>
<td>Explosives detection</td>
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Capability needs identified

- Point detectors that can detect and identify a large range of toxic and radioactive substances, biological agents (including viral agents) and explosives or explosive precursors.
- Low-cost sensor tags that detect for example harmful agents in containers.
- Standoff sensors for the detection and possible identification of biological/chemical (BC) agents and hidden weapons or explosives for improved passenger scanning at airports, harbors, building entrances and for the transportation system in general.
Capability needs identified cont

- Persistent small-area and all-weather surveillance for protection of critical infrastructure and for better situation awareness during or after harmful events, such as disasters and crises.
- Sensors that can detect humans or vehicles through vegetation and through walls or rubble, for activities such as search & rescue and surveillance in complex environments.
- Remote sensing (satellite, airborne and ground-based) for improved climate and environmental monitoring and for security applications, such as ocean security.
Detection of explosives, BC agents and other dangerous substances

Examples of current funding

- SSM/MSB
  - Development of methods to determine doses after nuclear and radiological events (SSM+MSB, LiU, Eva Lund)
  - Maintainance of competence to measure radioactivity in the field and in lab. (SSM, LiU, Eva Lund)
  - MSB in co-operation with DHS; CEREX (FOI)

- The Swedish national security research program 2007
  - DETEX (FOI)
  - EVENT (LiU)

- EU funding
  - FP7:SEC; IMSK (FOI)
  - FP7:SEC; EFFISEC (FOI)
  - FP7:SEC; LOTUS (FOI)
  - FP7:SEC; OPTIX (FOI)
• Retrospective dosimetry following Radiological-Nuclear (RN) accidents/events: Dose and risk assessment, Forensic analysis

- Hair: α-spec, γ-spec, ICP-MS, EPR
- Teeth: EPR
- Lung: HPGe, NaI
- Urine: α-spec, γ-spec, LSC
- Whole body: γ-spectrometry
- Thyroid: γ-spectrometry
- Nails: α-spec, γ-spec, ICP-MS, EPR
- GI-tract: γ-spec, α-spec
- Bone (biopsy): EPR
- Bone marrow/blood: FISH, etc.

Dosimetric methods used for developments at Radiation Physics

Eva Lund and Håkan Petterson, LiU-IMH
Standoff Detection of Explosives

Detection of objects in line-of-sight
Detection and Identification of 2g TATP at 200m distance through a double window

Detection of hidden objects by emitted vapour
Resonance Raman Spectroscopy enhances the signal strength so that detection of explosives vapor at a distance is possible

<table>
<thead>
<tr>
<th>Substance</th>
<th>$\lambda_{\text{max}}$ (nm)</th>
<th>$\omega$ (cm$^{-1}$)</th>
<th>$\sigma$ (cm$^2$str$^{-1}$)</th>
<th>Temp.(°C)</th>
<th>Conc. (ppm)</th>
<th>$F_{\text{max}}$</th>
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<tbody>
<tr>
<td>NM</td>
<td>232</td>
<td>1374/1394</td>
<td>$8.3\times10^{18}$</td>
<td>18</td>
<td>32500</td>
<td>2,200</td>
</tr>
<tr>
<td>2,4-DNT</td>
<td>~260</td>
<td>1353</td>
<td>$2.2\times10^{18}$</td>
<td>95</td>
<td>432</td>
<td>45,000</td>
</tr>
<tr>
<td>2,4-DNT</td>
<td>~250</td>
<td>1353</td>
<td>$5.1\times10^{16}$</td>
<td>81</td>
<td>126</td>
<td>100,000</td>
</tr>
<tr>
<td>2,4,6-TNT</td>
<td>250</td>
<td>1347</td>
<td>$6.0\times10^{17}$</td>
<td>128</td>
<td>341</td>
<td>12,800</td>
</tr>
<tr>
<td>2,4,6-TNT</td>
<td>248$^1$</td>
<td>1347</td>
<td>$2.8\times10^{18}$</td>
<td>96</td>
<td>26</td>
<td>57,000</td>
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</tbody>
</table>

$^1$ Used as reference or additional information.
EVENT - Event detection in crises management systems
Applied to anomaly detection in drinking water systems

- LiU/IFM/S-SENCE
- Linköpings kommun
- Saab Security
- Tekniska Verken i Linköping AB
- Adixen Sensistor

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Crises management system

Information

Network detection and interpretation

Sensor data

Sensor - "electronic tongue"

Drinking water system with chemical sensor network

Local detection

Sensor data

Anomaly detection

Substance separation

Threshold

0.5% Sewage water

Log Likelihood

PC1 (83.6%)

PC2 (5.2%)
Bio-aerosol detection

Laser-based techniques has a great potential for both point and stand-off detection of bio-aerosol. We have mainly investigated ultraviolet laser-induced fluorescence (UV LIF) and laser-induced breakdown spectroscopy (LIBS), but also elastic and inelastic scattering techniques.

UV LIF spectra from individual bio-aerosol particles in an air flow.


P. Jonsson et al., Evaluation of biological aerosol stand-off detection at a field trial, Proc. SPIE 7484, 74840I (2009)
Biosensor detection of explosives and narcotics

H = Heroin
X = Ecstasy
A = Amphetamine
C = Cocaine

Cocktails in the high concentration regime ~300 pg/µl:

Ecstasy
Heroin
Cocaine
Amphetamine

Bo Liedberg et al.
LiU-IFM
Detection of explosives, BC agents and other dangerous substances

Coming funding

- FP7:SEC call 2; **PREVAIL** (FOI)
- FP7:SEC call 2; DECOTESSC1 (FOI)
- FP7:SEC call 2; TWOBIAS (FOI)
Persistent small-area and all-weather surveillance technologies

Examples of current funding

- The Swedish national security research program 2007
  - Radar eyes (FOI)
  - Infrared network cameras (LiU)
- FOCUS
  - Naval Radar (FOI)
  - Sparse Sensor Management (FOI)
- EU funding
  - FP7:SEC; IMSK (FOI)
  - FP7:SEC; SECTRIONIC (Chalmers)
Compact electronics for small-area, all-weather surveillance

Example of results: Low-cost, un-cooled infrared network camera.

Microbolometer (IR detector)

Readout electronics

A fairly unique know-how in Sweden and in Europe!

Signal processing

To camera network, PC, internet, etc.

IR image of a LiU student
- LiU/ISY
- Axis
- Faun

Division of Electronic Devices, ISY

Micro Dopplers signatures

Micro Doppler radar signatures is a potentially powerful tool to detect the activity of unauthorized persons around airports, harbours and power plants, where humans normally should not be present. We have built up simulation methods for humans and animals that have been validated against measurements.

Persistent small-area and all-weather surveillance technologies

Coming funding
- FP7:SEC call 2; SUPPORT (FOI)
- FP7:SEC call 2; SeaBILLA (FOI)
- FOCUS phase 2, Video Analytics (FOI), Outdoor area surveillance (FOI), Ground sensor surveillance systems (FOI and LiU), Marine radar (FOI)
Examples of current funding

- The Swedish national security research program 2007
  - Radar eyes (FOI)

- FOCUS
  - RF Sensor for Face Recognition Through Masking (FOI and Chalmers)

- MSB in co-operation with DHS
  - ISSI (FOI and Chalmers)

- EU funding
  - FP6:Euripides++; IMATERA (FOI and Chalmers)
  - FP7:SEC; IMSK (FOI)

- VINNOVA Forska och väx 2009
  - HumanFinder (Cinside, FOI)
Components for stand off scanners

Using the property of mm-waves to ‘see through’ obscurants such as clothing fabrics concealed weapons and explosives can be detected. A sufficient resolution at stand-off distances using a limited aperture size requires very high frequencies (above 200 GHz) where new integrated component technologies are needed for compact and cost effective systems. We have demonstrated state of the art 210 GHz receiver chips

Radar sensing through clothes, packaging, walls, rubble and debris

**Coming funding**

- FOCUS phase 2, Sub-mm imaging of faces (FOI and Chalmers)
- FMV support to ISSI (FOI and LiU)
- FP7:SEC call 2; SUPPORT (FOI)
Collaboration and cross disciplinary possibilities

Future funding possibilities

- MSB general call December 2009 (Coordination meeting tentatively 17/12, 10-12 at LiU-IFM in room Röntgen)

- VINNOVA ICT security call 2010 (Coordination meeting tentatively 17/12, 10-12 at LiU-IFM in room Röntgen)

- FP7:SEC call 4, 2010

- FP7:ICT call 6, 2010

- FP7:Space

- MSB funded collaboration between Security Link and relevant DHS centers of excellence

- Other Swedish Agencies (VR, SSF)

- Swedish and international industry
Collaboration and cross disciplinary possibilities

Tentative future collaboration ideas

- SAR-systems (FOI (Lars Ulander)-LiU (Fredrik Gustafsson, Zoran Sjanic)) The idea is to integrate the SAR and the navigation systems
- Sub millimeter radar image processing using 3D-surface extraction and image quality enhancement. (FOI (Mikael Karlsson)-LiU(Hans Knutsson, Fredrik Gustafsson)
- Through the wall imaging. An efficient use of this technique will require that one simultaneously uses several sensors which are dynamically employed and whose locations may initially be unknown. (FOI (Stefan Nilsson) and LiU (Erik G Larsson))
- Image processing of Raman signals (explosives detection) (FOI (Sara Wallin and Henric Östmark)-LiU(image processing group?)
- Algorithms for chemical sensor data (LiU (Mats Eriksson) – FOI (David Lindgren). Already initiated but requires continuation)
- Development of methods to measure low levels of radioactivity in drinking water (Eva Lund LiU-IMH and Mats Eriksson LiU-IFM)
- Detektion via retentionstid i kapillärer (FOI (Per Jonsson) – LiU (Ingemar Lundström))
- Radiometric mapping by helicopter following Radiological-Nuclear (RN) accidents/events (Eva Lund/Håkan Pettersson, LiU-IMH and ?)
- Sensors for container security (LiU(Anita Lloyd Spetz) – FOI (Anna Pohl)
- Invisible / transparent chemical sensors based on e.g. ZnO (LiU(Anita Lloyd Spetz) – FOI)
End users and industrial contacts

**Industry**
- Airborne Hydrography AB
- Consilium
- Aqcuris
- Omnisys Instruments
- Portendo
- Cinside
- SenSiC AB
- Biosensor Applications
- Axis
- Faun
- Saab AB
  - Saab Microwave Systems
  - Saab Bofors Dynamics
  - Saab Security

**End users**
- FortV
- LFV
- The National Police Board (RPS)
- Securitas
- Tekniska Verken i Linköping
- Security department of Linköping Municipality