

FOI in focus

Research for a safer and more secure future





Sweden currently faces more security challenges and threats, and of greater complexity, than it has in a long time. In times of insecurity we need knowledge and, not least, research, to an even greater degree in order to analyse and interpret the implications of the changes we face. At FOI we experience increasing demand for communication of the results of our activities to our main employers. Our experts are in heavy demand by both decision-makers and the media. At FOI we have the unique advantage of understanding the scientific world and communicating its results so that they are even more useful in supporting the build-up of military and civil defence capability. Our research is often at the point of intersection between defence and security, the civilian and the military. One research effort can deliver double the impact.

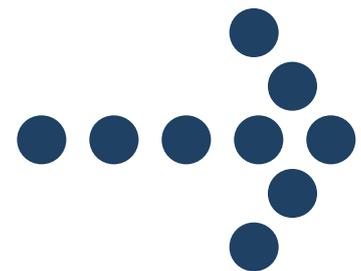
Interest in FOI's knowledge of security policy is great. We also notice that our expert know-how in different technical fields is in demand, for example, in research on the detection of homemade bombs, on cyberattacks, space issues, and hybrid warfare, to name a few. FOI has unique laboratory capacity within the entire range of CBRNE fields. Societal security and crisis preparedness are also areas where FOI contributes its knowledge and expertise for the benefit of on-going social debates. In its pursuit of a safer and more secure society, FOI has an important role to play in Sweden and internationally. In the following pages we highlight some interesting examples of all the projects and research fields in our extensive portfolio.

Jan-Olof Lind, Director-General of the Swedish Defence Research Agency, FOI

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Cover photo: The photo shows plates for generating electric fields in the FOI underwater laboratory. Read more about underwater research on page 17. Photographed in FOI's premises in Kista. FOI in focus produced in 2016.



Remotely-piloted vehicles create new challenges

How can small drones be inserted into general aviation? FOI conducts research not only on how to use this new technology in the best way, but how to protect ourselves from it.

Worldwide, the number of drones – also called Unmanned Aerial Systems, or UAS – has increased rapidly. From exclusive origins as a costly technology for military use, unmanned aerial vehicles are now mass-produced for a global market, easily purchased by individuals and companies alike. Their easy accessibility creates just as many opportunities as challenges. UAS expand our capabilities for reconnaissance, detection, and mapping. At the same time, they demand new thinking on civil security and personal integrity, terrorism, avoiding disruption of air traffic, and outdated legal systems.

Different kinds of problems can arise from the use of remotely-piloted vehicles. UAS have in some instances interfered with first responders and other emergency services. Developing methods that allow UAS and other aircraft to share the same airspace is one of the specific challenges that FOI focuses on. Another is FOI's search for means of protecting against the operation of UAS. In the event that a UAS flies in too close proximity to an airport, other infrastructure, or political events, protection

can involve locating both the vehicle and its operator, in order to immobilize their activity.

But these new technologies may also be of great benefit for society. FOI's experts are assisting the police, rescue service, and coast guard in preparing to integrate UAS into their operations by helping them to perform risk assessments. Sensors carried by UAS are helpful in real-time monitoring of disasters, detecting oil spills, and allowing overviews of a theatre of operations. Since there is no pilot on board to provide immediate judgement about the situation, it is important to foresee all eventualities. Numerous scenarios must be created and analysed so that the systems are prepared for unforeseen activities and the risks for all parties are minimised.

FOI uses UAS as a platform to develop technologies for peering around corners, finding victims buried under rubble, and searching for mines. These require robust systems with good endurance and reliable sensors. FOI's knowledge in the area of UAS has its foundation in working with the Swedish Armed Forces' systems, and that knowledge has been further developed for the benefit of all of society. ■



Smart sensors interact for security

Society's critical infrastructure is today protected by ever-smarter sensor systems. FOI is a world leader in the effort to achieve cross-fertilization between civil and military technology.

FOI is engaged in research and development of security systems founded on sensor technology and essential for civil society and the Swedish Armed Forces. The civilian systems are primarily designed for protecting infrastructure, such as nuclear power stations, server farms, embassies, and hospitals, which are critical to society. The military's equivalents are the bases of the Armed Forces. Each area's technological progress benefits that of the other. As the military sector pushes advances in ever more powerful sensors, the civilian sector pursues miniaturization in hardware.

The kinds of systems that FOI has been developing are especially effective in detecting threats at ever greater distances and earlier stages. This can involve the detection of individuals or other suspicious activity in prohibited areas, or of an armed intruder in an otherwise weapons-free zone, such as a courthouse, or airport. The trend is towards smart systems, where many sensors collaborate to identify threats, for example via deviations in patterns of movement. Systems, in turn, become better at deflecting false alarms,

a crucial concern for international peacekeeping missions and their military camps, which are often situated in urban settings.

FOI plays a world-leading role in developing new, more autonomous surveillance systems. Such systems are not only able to observe what is happening in their own surveillance area, but are adept at smart communication with other sensors in "reaching agreement" about what is occurring in a specific location, or area. The operator's job is simplified, since a much smaller number of computer screens are needed to monitor an event; today, the same task requires one screen for every sensor. The development of sensor systems is not only about technology. Applications in the civilian sector, especially, require systems that are ethically approvable and acceptable to those who are being watched. Together with external experts in ethics and law, FOI is studying how to ensure that future systems remain both within the limits of the law, and acceptable, in the society of today, and tomorrow. ■

Multiple benefits of FOI's research

Marine environmental research that the Swedish Navy can also use to adjust its sensors to their best advantage; or a positioning system for soldiers that could also save a firefighter's life. These are just two examples of the multiple benefits of FOI's research.

FOI's research is often focused on the common ground where defence interests and the safety of society intersect. This creates double utility and multiple benefits to society as a whole. The safety and security of Swedish society is today based on coordination between the requirements of military defence and of civil preparedness. FOI's scientists are able to place their broad technical expertise, which has been developed to meet military requirements, at the service of civil security. The Swedish military, in turn, can benefit from the research that FOI has performed in meeting the needs of civil security. Internationally, this pooling of knowledge to mutual

benefit is unique. Scientists at FOI also enjoy the unusual advantage of insight into the civil research at universities and colleges and can apply it to developing the military's capabilities, and vice versa.

The research undertaken by FOI for the Armed Forces, and for the safety and security of all of Swedish society, can also stimulate industrial innovation. FOI's world-leading research in sensor technology, for example, has led to development by Swedish vehicle component manufacturers of a unique system that warns drivers of pedestrians in the dark, and that can now be marketed globally. ■

Dual benefits. FOI's research develops both civil security and military capacity.

- The same technology that checks public transportation for hidden explosives is used by the Armed Forces in international and other operations to protect its soldiers from homemade bombs.
- Competence that has been developed for cyber defence also protects critical infrastructure, such as power plants and railways, from harmful trespass and sabotage.
- Knowledge of dangerous substances, so-called CBRN-substances, not only protects soldiers on international missions, but is used in disarmament negotiations and, at home, in the work that municipalities do to ensure environmental quality, for instance, in detecting toxic substances in drinking water.
- Military positioning systems that function even where GPS technology cannot, can also keep track of soldiers on international duty, follow firefighters and police rapid response teams during a crisis, and serve as a navigational aid for blind people.
- The Södertörn Fire Brigade ended up with a command vehicle that is both cheaper and more capable than the available alternatives thanks to access to the Armed Forces' experience in improving its command centres.
- Inspired by the civilian game industry, FOI has created a helicopter simulator that makes it possible to calculate how to best avoid being hit by a missile or machine-gun fire.
- A miniature air quality tester used by Swedish forces on international operations can also sample air quality in mining industry, the forest products industry and specific traffic environments.



Wise decisions rely on sharp analysis

Sweden's security has been affected by changes in its neighbourhood. FOI's studies and analyses in the overlapping zone where military thinking and politics intersect increases the decision-making capacity of Sweden's leaders to make the right policy choices.

The risk of armed conflict in proximity to Sweden's borders has long been considered non-existent. The Russian invasion and annexation of Crimea, in 2014, was thus a rude awakening. This was also followed by aggression in eastern Ukraine and Russian posturing activities in the Baltic. Many political observers fear that the Baltic countries, even if they are members of NATO and EU, may be attacked. In this context, Sweden can no longer be seen as one of Europe's quiet peripheries. The new security situation can have major implications for Sweden. Both the actual impact of a crisis, and the influence that Sweden's actions have on how other countries perceive it, are important dimensions of the changed circumstances.

The Government has instructed FOI's analysts to increase our knowledge of the situation and what it can lead to, so that Sweden can assess every set of circumstances correctly. The broad competence that is needed to

perform this type of analysis is in Sweden collected only at FOI. Knowledge of strategy and policy are needed, as is competence in technology and the social sciences. Since the analyses to a great extent consist of assessments and judgements, it is essential that the analysts avoid preconceived notions and superficial opinions. Carefully appointed working groups with deep background knowledge, long experience and mixed approaches to the topics in questions are essential.

A renewed analysis of Sweden's immediate neighbourhood was begun during the autumn of 2015, by reviewing open source studies, visiting important locations and holding discussions with key figures. That work will be followed up with more extensive analyses that will be delivered to the Government during the years to come. FOI's studies and analyses help Swedish policy to make our neighbourhood a little bit less unstable and in that way more secure for the people of Sweden. ■

Training to secure the information society

Cyber attacks can occasionally be prevented using advanced technology, but awareness and training are usually more effective. The training platform, CRATE, and related applied research are FOI's contributions to cyber security.

The success of Swedish society is based in large part on trust, between individuals, organisations, and society. This is an excellent quality, but not always for cyber security. In this domain, such remarkable trust in others has meant that in many respects cyber security is at the same level as the year 2000, with the difference that those who would damage others have become ever more successful. Cyberattacks are today often led by organized crime, or states. Crimes cover the entire spectrum from emptying the bank accounts of individuals and blackmailing companies to attacks on critical infrastructure and attempts to uncover defence secrets.

FOI's cyber security group compares the maturity of today's information society with automobility at the beginning of the 1900s: people can drive, but lack training, seatbelts and airbags. FOI, then, sees its task as raising the level of competence, primarily via training. CRATE, the Cyber Range and Training Environment, is possibly the

most important component of FOI's approach. Technicians, primarily from the armed forces, government agencies, and companies are invited here to undertake experiments and exercises. Participants practice emergency response under realistic conditions. This includes training in the defence of a network under attack and of how important it is to collaborate with other actors.

CRATE provides a platform for research and support in cyber security, which also includes research in human-cyber interactions. FOI also collaborates nationally with Swedish universities and internationally, for example, via EU projects.

The courses and research it conducts are an important aspect of FOI's vision of an information society and Internet where one can have the same trust in others as one does in the "normal" world: a world where one can click on links without worrying that one's computer will be plagued by viruses and Trojan horses. ■

This miniature world is used for training cyber security in the information society.
Photo: FOI



The new relevance of civil defence

The current security situation requires that Sweden activates and modernizes its civil defence. Government authorities, regions, county councils, industry and individuals must be able to fulfil their duties even in wartime. FOI supports society in this work.

At the end of the Cold War, Swedish politicians considered that there was little or no risk that Sweden would be exposed to military attack. Since security was to be assured through interventions in conflict zones overseas, national defence was toned down. Civil defence preparations were mothballed, and crisis preparedness for events in peacetime, such as storms, floods, and serious accidents, was developed instead.

Recent events in Sweden's surroundings have led politicians to reassess the situation. National defence must be strengthened and civil defence reconstructed. But, because society has changed during the many years when civil defence has been dormant, much of the earlier system has become obsolete. Many of those who are now in charge of

this transition have no personal experience of civil defence activities. There is a general sense of uncertainty about what a modern civil defence requires of various actors.

FOI has worked on total defence and crisis preparedness for many years, under assignment from several ministries and authorities, in performing studies of specific questions as well as providing support through on-site operational analyses. Security policy and technical researchers at FOI also provide up-to-date knowledge of global developments, threats and opportunities. These expert activities make FOI a natural partner for MSB, the Swedish Civil Contingencies Agency, and other actors that have important roles in civil defence.

Three essential challenges are highlighted by FOI in its work to create a modern civil defence:

- the ability to manage the transitional grey area from peace- to wartime organization of society
- the integration of civil defence with the current crisis management system
- the need to balance the various civil defence priorities so that an overemphasis on support for the Armed Forces can be avoided. ■

EU helps Sweden to develop its crisis preparedness

An FOI platform increases the benefits that Sweden receives from EU's Horizon 2020 framework program.

In order to deal with ever more complex, uncertain and multi-faceted risk profiles, Sweden's civil preparedness system requires increased resources. Cooperation with others also distributes costs. The networks, outcomes, and participation in EU projects can inspire development and make it more effective. FOI has experience from involvement in over 150 EU-financed projects. MSB, the Civil Contingencies Agency, has now entrusted FOI with developing the H2020 Secure Societies Coordination Platform, so that the impact of the EU dimension in Sweden's efforts in civil preparedness can be strengthened. EU's projects within H2020 Secure Societies are intended to contribute

to increasing the capacity to predict, prevent, and deal with threats through innovative technologies, solutions, forecasting tools, and new knowledge.

The Coordination Platform is directed at all actors involved in civil preparedness, both those who already have capabilities and those who are actively developing them. The Platform creates venues where the needs of different actors can be gathered and matched with research calls and where collaboration on proposals can take place. It is being developed in stages in consultation with those Swedish actors that have responsibility for the crisis preparedness system. ■

www.foi.se/plattform



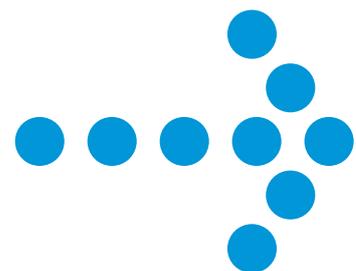
On assignment in Mali

Since 2015, a Swedish military force is on UN duties in Mali. This is a first for intelligence units in Sweden's UN operations.

FOI has experts in the politics and policy of African security, in the workings of the Armed Forces, as well as in peace support operations. Close cooperation between several of these core competences is required to provide support for Sweden's efforts in Mali.

The Ministry of Defence has assigned FOI the task of following up all Swedish military contributions to peace support operations. Those efforts shall strengthen Sweden in its role as an actor in peace support and ensure that its contribution has the greatest possible effect. By extension, Sweden can assist the UN in developing its peace support activities and in creating ever more modern capabilities. The mission in Mali provides experience that will also be useful in future operations.

FOI's experts provide specialized support in African security policy and conflict studies. This provides Sweden's Government Offices with a better understanding of complex events as it conducts its operations in what for them is a new area. ■





Laboratories in pace with a changing world

When the Organisation for the Prohibition of Chemical Weapons, OPCW, trains its staff to work with chemical weapons, it chooses to send them to FOI's laboratories. These labs are where various authorities bring suspiciously dangerous substances and where companies turn when they wish to test analytical and protective equipment.

FOI's facilities are among the select few laboratories in the world that are certified by the OPCW to carry out its tests. Most recently, samples were sent from Syria to test whether chemical weapons had been used in the civil war. This is a research field that FOI is concentrating intensely on. For example, it has developed a new method for being able to test in a laboratory, through analysis of bodily fluids and other substances, whether people have earlier been exposed to chemical weapons.

FOI's various laboratories play an important role in efforts to ensure a more secure society by providing support to Swedish and European authorities, organizations and companies in their work with security.

The toxicology lab is a unique high-security laboratory, one of the few that can handle nerve toxins so potent that a drop the size of a pinhead is deadly. This is where material that is suspected to be dangerous is sent for analysis, once it has first been identified as neither radioactive nor contagious.

FOI's biosafety lab is designated as a safety level 3 (of 4) facility, which means that its personnel are able to work with almost all known materials, not least those that can be spread for antagonistic purposes.

The radiological laboratory collaborates with other world-leading labs in the area of forensics to develop methods of, for example, tracing radioactive material to a specific source, or producer, in connection with terrorism. The lab also has an important role in the event of nuclear accidents. It continues to monitor the radiation from the disaster at the Chernobyl nuclear power plant by, among other things, checking radiation levels among the Sami people, who were hard hit by the presence of Cesium 137 in reindeer meat.

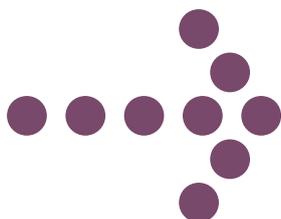
FOI's materials laboratory measures how well different materials protect against dangerous substances. Textiles, gloves and footwear, primarily, but also the effectiveness of filters in both protective masks and shelters. The work includes finding weaknesses in protective clothing, not

only by testing how resistant they are, but how well they function in normal use.

The research undertaken in FOI's laboratories is partially financed, respectively, by the ministries of defence and foreign affairs. But many other Swedish authorities – for example, MSB/ The Swedish Civil Contingencies Agency, the Radiation Safety Authority, the Public Health Agency, the Board of Agriculture, and various other emergency responders – rely on the knowledge and resources of FOI's labs.

International organizations that FOI collaborates with in the frame of EU and military cooperation are also among those that commission its services. Businesses, for example producers of measuring equipment, also approach FOI, since its high degree of integrity is seen as guaranteeing its reliability as a partner. FOI's most important condition for allowing its laboratories to be at the service of a client is that the collaboration provides value-added in the form of an increase in its own core competence.

FOI's laboratories are evolving in pace with their environment. In the near future, the focus will be on attaining an overview of technological development in Sweden's neighbourhood, specifically the extent of military build-up and terror threats. ■



Swift analysis helps the UN

In August 2013, reports were received that a large number of people had died following an attack on the Syrian city of Ghouta, to the east of Damascus. The UN requested an immediate inspection. In September, only a short time later, an aircraft carrying samples from the suspected chemical weapons attack on Ghouta landed at Umeå airport, where FOI's chemical weapons laboratory is located. Some ten laboratory personnel then worked in shifts 24/7 in order to produce results as quickly as possible.

Before long, it became clear to the analysis group in Umeå that the samples contained sarin. After just one week, FOI's scientists were so certain of their results that they were able to inform the OPCW that traces of sarin had been found. Four days later, they submitted a full report that definitively confirmed the results. Only thirteen days after the arrival of the samples in Umeå, the final conclusive report was handed to the UN Secretary General. The scientists at FOI's laboratory had carried out a unique analysis in the midst of events of global significance.

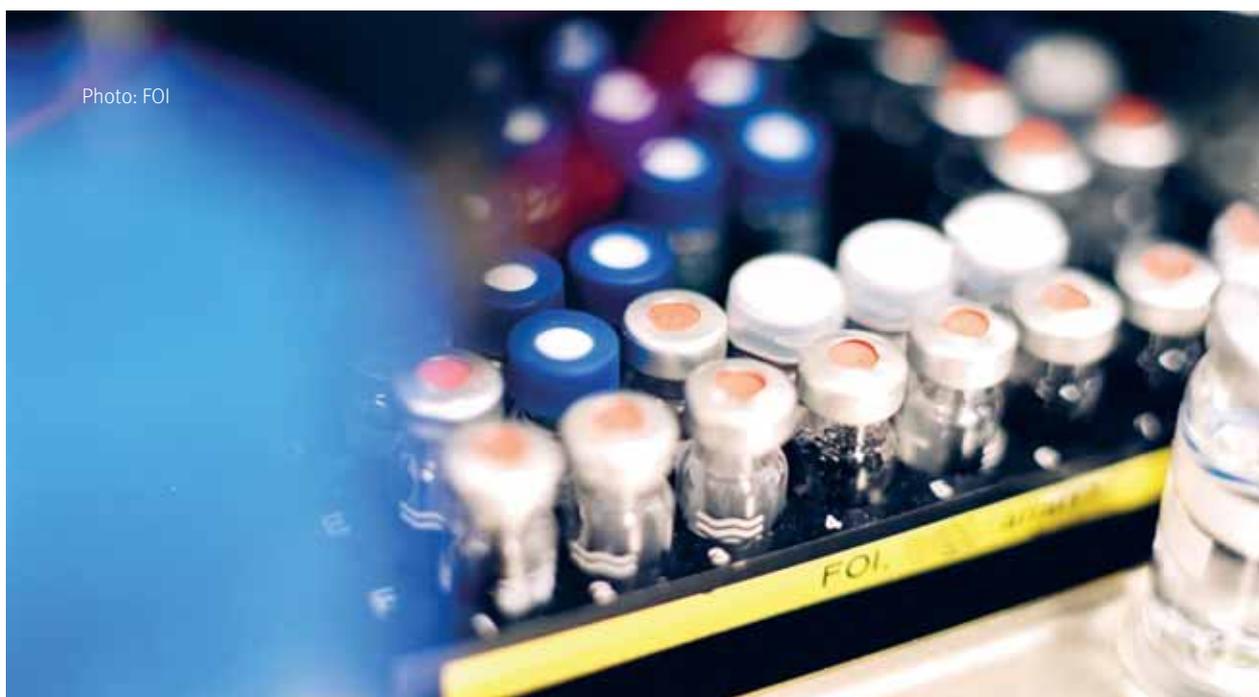


Photo: FOI



Flight simulators take training to new heights

At FOI groups of Gripen pilots can train simultaneously against or alongside intelligent computer-generated forces in the Swedish Air Force Air Combat Simulation Centre (FLSC). It is a facility that just keeps getting smarter.

In the simulator at the FOI facility in Kista in Stockholm up to eight pilots can train at the same time in a cockpit environment that resembles the one in a JAS 39 Gripen. The missions are directed by up to four combat air controllers. The aim of the simulations is to develop the cooperation and interaction between pilots and controllers at a tactical level in a combat environment. The scenarios played out, produced by FOI's personnel and visiting Gripen fighter squadrons, can include land, sea and air threats.

The results are tangible. The Swedish Air Force becomes sharper as its pilots not only train together but also develop individually. The armed forces save time and money, since the alternative to simulation is to fly real sorties. "Real" missions with so many planes at the same time is seldom possible except during large exercises. The facility can also be used by other nations that fly the Gripen, which in turn a boost to Swedish efforts to increase exports.

The simulator facility's system of intelligent computer-generated aerial forces has been created by FOI's researchers. The behaviour of the forces has been designed with the aid of deep interviews with actual pilots; their role in the simulations can be configured for either side, as either enemies or friendly forces. The trend has been toward ever more autonomous computer-directed forces, so that the role of enemy does not have to be played by actual pilots. This means that pilots who travel to FOI to use the simulator can concentrate on their own training. Current upgrades to the FLSC system enable the navy to participate in simulations, which facilitates training for coordinated air-sea battles.

Another refinement to FLSC is the inclusion of an electronic warfare capability, which allows pilots to jam the enemy and an opportunity to practice in a radio- and radar-jamming environment. ■

The hunt for illegal jamming transmitters

Disturbance of unprotected wireless equipment by radio jamming devices has increased in recent years. It afflicts both civil authorities and private citizens.

Organized crime uses radio jamming equipment to disrupt alarm and security systems in stores, private homes, and cars. An alarm that is based on GPS can be easily disabled simply by disturbing the signal. Small, inexpensive transmitters that can do just that are now on the market. A jamming signal prevents your car from locking itself when you press on the key as you walk away. While you're having a coffee, thieves empty the car of everything you've bought while shopping that day.

FOI's experts are continuously discovering new ways in which jamming devices are being used, and searching for techniques to discover and neutralize them.

A system has been developed that monitors the areas where the affected frequencies are relied on; parking lots, for example. If a jamming device in the area is detected by the system, it sends an alarm so that the police can look for the perpetrators and home in on the signal source and remove it.

Many of society's essential activities are completely reliant on wireless technology. This is the case, for example, when first responders, the police and fire-fighters, are called in. Since sensitive wireless systems have increasing applications, FOI is investigating how wireless communications equipment and GPS receivers can be made more resilient. An advanced laboratory, with a simulator and test environment, along with field trials, are used by FOI to improve GPS, both for the Armed Forces and industry.

The combination of working with military applications – with their criteria for robust, jam-proof technology – and possessing deep knowledge of civilian applications with high-speed commercial radio traffic, results in broad competence. This allows FOI's experts to assist both the Armed Forces and other authorities in obtaining optimum results from these systems. ■

Electronic jamming devices don't have to be large, and they are easy to obtain. Photo: FOI





Street photo: Stockholm's Bryggare Street one year after a suicide bomber's attack.
Photo: Tomas Oneborg/SvD/TT

Helping to defeat the bombmakers

FOI assists the EU and Swedish authorities in their efforts to foil terrorist bombings. Its experts continue to learn more about how building do-it-yourself bombs and suicide bombings can be stopped, without fatalities.

Forty kilometres south of Stockholm, at lake Grindsjön, FOI has an extensive facility for testing and detecting explosive materials and devices for civilian and military use. This is where a major portion of the Swedish Armed Forces' knowledge of explosives, explosive effects and their assessment has been accumulated and acquired, know-how that has proven invaluable in international peace support operations.

The civil sector – the Police and MSB/Civil Contingencies Agency, among others – has become increasingly aware of FOI's unique expertise. The European Union has also granted major contracts to FOI, which has coordinated eight of the EU's projects in the Security of Explosives area. These cover the entire spectrum from discovery of chemical methods for preventing bomb-making to studies of how attacks are carried out and who is behind them.

An important area of research is the identification and mapping of trade in the materials that do-it-yourself bombers can use to make explosives. Ordinary store-bought substances that are not in themselves dangerous can be combined to deadly effect. New materials that can be used in such "garage lab" production are continuously identified and mapped. FOI's scientists must track down and test various "recipes" that are circulated on the Internet, and elsewhere, so that the potential for using simple additives to neutralize the use of specific materials in bomb-making can be better understood and applied. A guide is also being produced to help police and other first responders know quickly whether they have arrived at an improvised bomb factory.

FOI's experts also have an important role in a European research group that is studying operational and technical methods for stopping a suicide-bomber by

non-lethal means. FOI's focus is to assess the effectiveness and risks of using conducted energy weapons, such as Tasers, to intervene against a suspect.

The approximately one hundred researchers – physicists, chemists, and engineers – who work at the Grindsjön facility are involved in the daily effort to find and stop bombmakers. Some scientists are developing sensors that can detect traces of explosive substances in the air and in sewage. Others are improving the possibility of preventing attacks by designing a detector that can reveal explosive traces in suitcases, or on the rim of a vehicle's steering wheel. Another example of preventive research is to find methods for short-circuiting a bomb's detonator.

If the worst happens and a bomb does detonate, the scientists at Grindsjön can assist by using the forensic methods that they have developed and refined, to establish what the nature of the explosion was, the identity of those behind the attack, and its consequences for society. ■

An excellent facility for bomb detection

Extensive resources are located within the 7,5 km² compound at Grindsjön. The installations include:

- A firing range for testing missiles, rocket motors, and warheads, in a hazard area with a 600 m radius.
- High-speed filming capability.
- Facilities for analysis and characterization of both explosive and unclassified materials.
- Upscaling and up-conversion possibilities for explosive and unclassified materials.
- Facilities for producing explosive charges.
- Processing of gunpowder and explosives.
- Accelerated aging of ammunition, gunpowder, and explosives.
- A small-scale underwater testing basin.
- Optics and laser activities.
- High-voltage laboratory with access to several hundred kV.
- Mechanical workshop.
- Rifle range with military status.
- A light gas gun facility with small-calibre laboratory.
- A catapult track capable of testing materials at up to 80,000 g.



Photo of researchers: Photo: FOI



Space matters – but how?

The technological exploration and commercialisation of space are proceeding rapidly, as is the number of actors who are active there. FOI is keeping close watch and providing support to the Armed Forces, FMV/Defence Materiel Administration, and the Ministry for Foreign Affairs, in space matters.

A big part of today's infrastructure is controlled from space. This makes military systems and critical infrastructure increasingly vulnerable to space-based interference and creates a number of difficult questions for the formulation of Sweden's national space policy. As part of addressing that challenge, FOI's experts participated in the government's recent commission on space policy and contributed to proposals for a national space strategy, primarily in the form of briefings on the research and analysis of global developments that it carries out continuously.

FOI's experts also provide similar support for the Armed Forces' development of space capabilities. This is most visible in a broadly-circulated newsletter that describes trends, new technology, strategy, policy and how other countries are active in space. The FOI experts are currently developing their expertise in space situational awareness.

Such space situational awareness complement other

situational awareness of, for example, air, land and sea.

Space awareness also constitute an inventory of the objects currently in space, including satellites and all forms of space "junk." What is passing over our country in space at this moment? What purpose do they have and how and when do they pass? By developing algorithms, calculating and predicting satellite orbits, and via practical experiment, FOI's experts are uncovering and accumulating new knowledge that is useful for the future of Sweden's space capabilities.

FOI's global analyses and overviews are also useful when Sweden meets with other countries to work with keeping space free from crisis, war, and arms. What do other countries think and what are their intentions?

How are they investing in various space projects? Why? FOI's space experts supply the Ministry of Foreign Affairs with reports and technical background material that are useful in its international negotiations. ■

Specialists in supporting underwater defence

The security situation in the Baltic requires that Sweden is constantly vigilant in detecting and pursuing hostile underwater intruders. FOI's knowledge is a unique contribution to that capability.

When the Cold War ended, major elements of Sweden's system for surveillance of its territorial waters were dismantled. At the same time as tensions in Sweden's neighbourhood are increasing, so is the need for renewed alertness about all underwater activities.

The underwater environment of the Baltic Sea is notoriously difficult to monitor. It is a "noisy" sea, which makes it a challenge to detect signals from foreign submarines and other underwater craft. This is doubly difficult because it is easy for intruding vessels to hide among the contours of its uneven seabed. FOI's research in detection, classification and identification of sounds in underwater environments is world renowned. Cooperation with its experts is in wide demand, not only in Europe and in the United States, but in countries such as Australia and Singapore. International collaboration is not only an indication of successful research, but an opportunity to gain new knowledge. That knowledge is well-placed in the efforts of the Armed Forces and FMV/Defence Materiel

Administration to reinforce the protection of Sweden's territorial waters. FOI's unique knowledge of sensors and of how sound signatures propagate in the Baltic is a vital component of an underwater surveillance system. FOI's analyses of the military are useful when assessing the capacity of other countries to wage war and their manner of communicating under water. Research on new sensors, weapons systems, countermeasure systems and tactical support systems for underwater operations continuously develops the navy's fighting effectiveness. Its operations are further strengthened by FOI's development of interconnected sensors, weapons and protection so that they can communicate during rapid interventions.

FOI's research is led by senior scientists who have played a part in constructing Sweden's modern underwater defence. With reinforcements of newly graduated scientists who bring the latest in cutting-edge knowledge, FOI now has a unique competence in underwater systems. ■

Corvettes training antisubmarine warfare.
Photo: Magnus Jirlind/Swedish Armed Forces





Web analysis uncovers net criminals

By filtering and analysing large quantities of data, FOI can assist law enforcement authorities, for example in revealing criminals who use the Internet to sell narcotics.

Narcotics, weapons, and other illegal products are sold on Internet via unlawful markets on the so-called “Dark Web.” These are hidden websites where buyers and sellers can remain anonymous by using various technical aids. The visitor installs software that shields his or her identity, at the same time as the actual website’s address and existence is hidden. Illegal activities can proceed relatively undisturbed and without much risk of interference from the police or other crime-fighting authorities.

FOI has established a high level of competence in web analysis, which can help the police to uncover criminal activities on the Internet. Sifting through enormous quantities of Internet data and social media to find something useful requires special kinds of hardware and software. The police, customs, and other authorities can use advanced web analysis to obtain a better understanding of what types of

drugs are arriving in Sweden, how they are transported and delivered, and who the buyers and sellers are. New methods can assist the police in discovering who the large-scale sellers are.

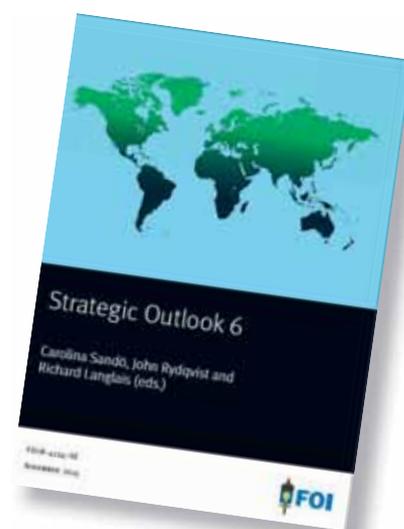
Technology is being developed that makes it possible to destroy the anonymity and reveal the identity of otherwise hidden criminals, such as major drug dealers. There are now a number of ways of doing this. One way is to perform automatic analyses of what a person has written, or the way in which they write, including the topics and their personal style. The computer program collects and assembles profiles based on the texts of users, and compares and matches the profiles with those of already-known identities or suspects. It is also possible to use author recognition and text analysis to establish whether different aliases on the Internet actually belong to the same person. ■

FOI peers into the future

What security challenges will Sweden face in the years to come? Some of the answers can be found in the recently published sixth edition of the respected FOI report series, *Strategic Outlook*. The fifteen articles in the report discuss a number of technical and security policy dilemmas, trends and challenges that may grow to have important implications for national and global security.

Strategic Outlook addresses matters ranging from the reconstruction of Sweden's civil defence and information warfare in the Baltics to questions raised by the return of nuclear weaponry, the networked society and security in outer space. FOI's analysts and researchers also discuss Sweden's need of a grand strategy, regulations for drone use, underwater technology, and innovation in defence economics.

The articles are based on a selection of the analyses and research work carried out by FOI's staff of some 770 analysts, scientists and engineers. ■



Learning through training provides security during a crisis

It is when a crisis actually occurs that the benefit of training becomes obvious. FOI can provide support to every phase of society's exercises in civil preparedness, from working with scenarios to evaluation.

The evaluation is often the most important reason for holding an exercise. Evaluation creates a bridge between training and improvements, and an increase in the knowledge of the participants, as well as improvements in the understanding that society's actors have of each other.

FOI's engagement in crisis exercises and their evaluation began approximately twenty years ago. An important aspect of that work is to support the actors in the complex coordination exercises (SAMÖ) that are arranged by MSB/Civil Contingencies Agency. The Armed Forces, the Police, the emergency services, and the health services also engage FOI in similar work. The optimum outcome is obtained by those that include FOI in every stage of the process, so that already in the planning stage there is an awareness that an exercise needs to result in a useful evaluation. FOI's evaluation groups can contribute during the entire exercise by photographing, filming and collecting data. Other aspects of an exercise

require subjective judgement in order to understand what is happening, and this is where the broad experience provided by FOI's observers are a real asset. FOI also has a broad pool of competence to draw on amongst the rest of its personnel, who can be called in as experts, analysts, or advisers, as the need arises.

By participating in every phase of an exercise, FOI can play a natural role in an exercise, with its integrity remaining intact. This means that the organization that has commissioned the exercise, as well as its participants, can view the evaluators as constructive partners in a dialogue.

The organizers of the exercise can afterwards use the data collected for justifying their assessments of the participants' actions. A greater degree of learning is achieved when all of the participants can see their own behaviour in relation to others'. Society receives a greater return on its investment and an increase in security and defence capability. ■

This is FOI

FOI is one of Europe's leading defence and security research institutes. Although FOI is a public authority under the Swedish Ministry of Defence, the majority of its work is client-commissioned and funded. Our largest clients are the Swedish Armed Forces, the Swedish Defence Materiel Administration (FMV), and the Swedish Civil Contingencies Agency (MSB). We also receive many assignments from the civil sector, including industry and a range of public and local authorities, primarily in the fields of emergency preparedness and security, as well as from other countries.

Within FOI we undertake research on security issues at all levels – international, intra-EU and national, as well as at regional and local levels.

Because our research focuses on many different levels and on a wide range of fields, by working together FOI's research teams are able to create integrated overviews of how developments in both society and technology interact. This creates a unique opportunity for FOI to discern potential risks and threats at an early stage and thereby develop sustainable solutions that can counter them.

We perform security analyses and assessments of different kinds of threats. We are leaders in submarine research and in research relating to explosive substances. Our areas of research also include aero systems, ICT security, radar, laser, and other sensor systems, as well as protection against hazardous substances. FOI's know-how is in much demand internationally and we lead several EU projects.

The agency has approximately 930 employees, of which approximately 770 are researchers at academic level. FOI employs physicists, chemists, chartered engineers, social scientists, mathematicians, and philosophers, engaged in research, methodology and technology development, analyses, and studies.

FOI conducts research and technology development. Our R&T is conducted with a long-term perspective on the need for basic research at the same time as, in the short-term, it develops knowledge-based applications. Along with our analyses and studies, our research and development is always directed at meeting the current needs of our clients. We work for a safer and more secure future. ■



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