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Technological trends and their impact on defence planning

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John-Mikal Størdal, *Director General*

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Summary

In this report on defence technology, FFI points to some of the technologies that have the greatest significance for the Norwegian Armed Forces, both in the short and long term.

Technology is a pervasive phenomenon with fundamental impact on developments in the sector. It is an independent development in itself, but affects others – including security policy. Technology development must be seen in close connection with the development of personnel, organisations and operational concepts.

FFI recommends that the following priorities be taken into account:

- The defence sector must increase the ability and willingness to utilise new and existing technology and get it out to competent users quickly. A holistic approach should be facilitated in which technological opportunities and vulnerabilities are assessed together with the development of doctrines, concepts, competence and organisation. Alternative concepts and new technologies must be considered more systematically and effectively early in the materiel procurement projects. This requires broad analyses with emphasis on functionality.

- Developments towards high-tech Armed Forces should be continued and research, development and innovation aimed at military technology and military systems should remain a priority. This technology development is essential to meet the specific military needs and high demands of robustness and endurance in crisis and war.

The recommendations can be translated into the following advice:

1. We should prioritise the development of modern, high-tech Armed Forces.

2. We should rectify significant technological vulnerabilities.

3. We should invest long term in the most attractive technology areas.

4. We should build a stronger innovation culture in the Armed Forces.

Sammendrag

I denne rapporten peker FFI på noen av de teknologiene som har størst betydning for Forsvaret, både på kort og litt lengre sikt.

Teknologi er et gjennomgripende fenomen med fundamental påvirkning på utviklingen i sektoren. Det er et selvstendig utviklingstrekk i seg selv, men påvirker andre – også sikkerhetspolitikk. Teknologiutviklingen må sees i nær sammenheng med utvikling av personell, organisasjon og operasjonelle konsepter.

For å sikre et effektivt og relevant forsvar anbefaler FFI at følgende prioriteringer legges til grunn:

- For best å nyttiggjøre seg teknologien må forsvarsektoren øke evnen og viljen til å utnytte ny og eksisterende teknologi, og få den hurtig ut til kompetente brukere. Det bør legges til rette for en helhetlig tilnærming hvor teknologiske muligheter og sårbarheter vurderes sammen med utviklingen av doktriner, konsepter, kompetanse og organisasjon. Alternative konsepter og nye teknologier må vurderes mer systematisk og reelt tidlig i materiellanskaffelsesprosjektene. Dette krever brede analyser med vekt på funksjonalitet.

- Utviklingen i retning av et høyteknologisk forsvar bør videreføres, og forskning, utvikling og innovasjon rettet mot militær teknologi og militære systemer bør fortsatt prioriteres. Denne teknologiutviklingen er avgjørende for å imøtekomme de spesifikke militære behovene og høye krav til robusthet og utholdenhet i krise og krig.

Anbefalingene kan omsettes til følgende råd:

1. Vi bør prioritere utviklingen av et moderne, høyteknologisk forsvar.

2. Vi bør utbedre vesentlige teknologiske sårbarheter.

3. Vi bør investere langsiktig i de mest attraktive teknologiområdene.

4. Vi bør bygge en sterkere innovasjonskultur i Forsvaret.

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Foreword

One of FFI's most important duties is to keep abreast of aspects of technological developments that may affect the conditions for defence policy, defence planning and the administration of the sector.

The ability to utilise new technology has a significant impact on defence capabilities. The current long-term plan is a major step in the right direction and the expert military recommendations recently submitted by the head of the Armed Forces provide a good basis from which to continue this.

In this report, FFI highlights some of the most important technological development trends of today and their significance for the Armed Forces in the short and long term.

Kjeller, 17 October 2019

John-Mikal Størdal

1 Developments in technology offer both opportunities and threats

Norway currently faces more difficult and complex security policy challenges and more rapidly changing technology than in the past. Over the last five years, security policy has been dominated by tension between the West and Russia, as well as a more complex threat landscape in Europe. More readily available technology is creating new threats to societal security, from both state and non-state actors, and the distinction between military and civilian technology is fading through a steady growth in products with both military and civilian applications. Norway also has strategic and geographical features that reinforce the significance and potential benefit of new technology.

This emphasises the need for the government to become more involved in the development of technology for military purposes. This is vital if we are to respond to technological developments being made by potential enemies and to work effectively with allies and the civilian element of our Comprehensive Defence.

In this report on defence technology, FFI highlights some of the technologies that have the greatest significance for the Norwegian Armed Forces, both in the short and long term.

Technology is a pervasive phenomenon with a fundamental impact on developments in the sector. It is an independent development in itself, but affects other areas as well – including security policy. Technological development should be considered in close connection with the development of people, organisations and operational concepts.

In order to ensure that the Armed Forces remain relevant and modern, FFI recommends that the following priorities be taken into account:

- In order to make the best use of technology, the defence sector must increase its ability and willingness to utilise new and existing technology and make it available to competent users quickly. A holistic approach should be facilitated in which technological opportunities and vulnerabilities are assessed alongside the development of doctrines, concepts, competence and organisation. Alternative concepts and new technologies must be considered more systematically and effectively during the initial stages of material procurement projects. This requires broad analyses with an emphasis on functionality.

- It recommends that developments towards high-tech Armed Forces be continued and that research, development and innovation aimed at military technology and military systems remain a priority. This technology development is essential to meet the specific military needs and high demands of robustness and endurance in crisis and war.

Figure 1.1 Instructor at the Royal Norwegian Air Force Tactical Flying School performs tests on Black Hornet drones (Photo: Simen Rudi / Norwegian Armed Forces)

Figure 1.2 The guardsmen in HMKG, scout the area to find a good position for a relay installation (Photo: Victoria Thorbjørnsen / Norwegian Armed Forces)

2 A changing world

Throughout the post-war period, the West, led by the U.S., has aimed for superiority based on staying ahead in terms of military technology. However, in the future we must be prepared for a situation in which non-Western countries and international companies have much of the same technology over which countries in the West have long had the monopoly. This has major implications for national security and the strategic choices underlying the continuing development of the Armed Forces.

We are seeing a power shift towards the East, particularly the emerging economies in Asia. This involves global economics and geopolitics, but also technology. In recent years, China in particular has invested significantly in new technology development and is already challenging the West's traditional military technology hegemony in important areas. Within fields like artificial intelligence, China has expressed the aim to become the world leader by 2030.

Parallel to this geopolitical power shift, we are seeing an increasingly important role being played by civilian companies in the development of technology. The major international technology companies are investing tremendous resources and becoming leaders in key areas within technology development. Technology is becoming faster and cheaper and advanced technology is now available to both state and non-state actors.

These global trends are amplified through the increasing significance of technology on social development, security policy and the balance of power. Historically, science and technology have generated conceptual changes for military forces. The introduction of technology such as aircraft, nuclear weapons, missile technology and precision-guided weapons have all resulted in entirely new operational concepts. Some of the technological advances of which we are now seeing the contours have a similar potential to create a fundamental change in sectors like defence.

3 Key areas for the application of new technology

A number of areas stand out as particularly interesting for the application of technology from a Norwegian standpoint. In the report 'How do we strengthen Norway's Armed Forces?' ('*Hvordan styrke forsvaret av Norge'),* FFI has pointed out that there is a particularly high degree of complexity and technological uncertainty involved in surveillance, threats from cruise and ballistic missiles and threats in cyberspace and electromagnetics. These are also technology fields that have direct relevance, both in terms of defence policy obligations and unique geographical challenges.

With respect to surveillance, a range of emerging technologies can be used jointly, can strengthen each other and can change the way in which the Armed Forces operate. Situational awareness and an up-to-date operational picture are vital for precision and pace in any type of operation and we see that challenges are moving towards more complex threats coordinated in several domains at the same time. **Sensors and sensor systems** connected to **unmanned platforms** could generate potentially significant benefits in terms of coverage and endurance. Developments in **information and communication technology** are making it possible to transfer, analyse and compare information more quickly and effectively. **Automated analysis** using machine learning is making it possible in principle to handle increased volumes of information of various types and from various sources, which could help to detect objects and incidents and obtain accurate information about a target. **Satellites** play a key role since they provide access to areas outside Norwegian control. Together with unmanned systems, they also enable coverage and endurance in areas that are difficult to access. Satellite-based surveillance could also result in cost-effective performance in peacetime. For a small country like Norway with large marine areas to monitor, the development of low-orbit satellites and autonomous sensor-equipped drones with a long-range and endurance are of particular interest.

Developments are expected in **weapons systems**, such as missile weapons, autonomous weapons systems, mass-effect weapons, target-specific mines and directive energy weapons, as well as in precision-guided ammunition. Long-range, high-speed missiles are widespread in the non-Western world and are contributing to an increased threat. For example, China and Russia have demonstrated that they have made great strides in the development of precision-guided, long-range weapons. However, in the West, high-technology missiles are also being developed with increasing ranges, lower signatures and higher speeds. Some countries are also developing nuclear weapons and this must be considered within the same context as developments in other weapons systems. Combined with the development of weapons systems, this will result in a race to develop protective measures. Defence systems against ballistic missiles are made up of several systems and involve collaboration within NATO and between allies. The Armed Forces currently have no sensors capable of detecting incoming ballistic missiles and no missiles capable of intercepting ballistic missiles.

The Armed Forces are also facing challenges in their future ability to develop **electronic information** in difficult conditions. Geographical conditions make it difficult to create robust communications systems in Norway. The Armed Forces' ICT systems must enable command and control and allow cooperation between the Army, Navy, Air Force, cyberspace, allies and the civilian element of the Comprehensive Defence. The need to exchange data and information in order to coordinate and lead operations is increasing. The current communication systems are inadequate and vulnerable when assessed against future requirements for operational tempo, collaboration, geographical coverage and redundancy. This applies at the strategic, joint operational and tactical levels. However, it is apparent that high-frequency communications systems are becoming significantly cheaper and more readily available on the mass market. Higher frequencies for communication improve transmission capacity and can also reduce the likelihood of both interference and jamming. Larger and smaller drones and satellites, as well as

Figure 3.1 Shooting NSM missile from a launcher mounted on a truck (Photo: Kongsberg Defence System / Norwegian Armed Forces)

Figure 3.2 Day sailing with HNoMS Utvær submarine. (Photo: Olav Standal Tangen / Norwegian Armed Forces)

the ability to use available networks ad hoc – e.g. commercial mobile networks – will make the system less vulnerable.

Military operations are also becoming increasingly dependent on the ability to control and utilise the electromagnetic spectrum. **Electronic warfare** (EW) plays a key role here. Communications systems, various types of sensors and weapons systems depend on this spectrum. In order to maintain combat power, it is vital that our forces are able to use EW and that they are prepared, through training and exercises, to resist and affect an enemy using EW.

The Armed Forces have developed capabilities and knowledge about the **cyber domain**, but despite this have limited experience in planning and conducting extensive military operations in cyberspace and integrating these into joint operations. The cyber domain is new, it has no geographic boundaries, and it involves a vast number of players (including non-military) and has numerous grey zones. A cyber-attack could affect us both directly (sabotage) and indirectly (reduced confidence in systems). The conflict in Ukraine and elections in the U.S. are examples of the cyber domain being used to attack and influence.

4 Important research areas for the development of military technology

Trend analyses from FFI, NATO and various international research communities show a relative consensus on which technological fields will have a major and increasing importance for military operations in the future. These are the technology fields in which constant advances are being made, but which vary in terms of how far development has progressed. However, what they all have in common is that they are technologies with a high potential of benefit for the Armed Forces and our societal security.

Developments in **advanced electronics and data processing** are important because almost all platforms, systems and services have a programmable element. Quantum computers are an immature technology and are far from ready for use by the military. Extensive research is being conducted in this field due to considerable civilian demand and a breakthrough could have a tremendous effect on complex, hyper-fast data processing. For military purposes, quantum computers combined with artificial intelligence could process enormous volumes of data and thereby solve problems that currently seem unsolvable, such as breaking encryption that has previously been secure.

Next-generation **sensor technology** will be able to detect signals with increasing sensitivity, discover more signal types and thereby improve our ability to identify and locate targets. New sensors will contribute with data sets from the ‘Internet of Things’, which will increase situational awareness. Much of the development is in the civilian field, but some areas will be

reserved for military development. From a military perspective, the focus should be on adapting and integrating sensors in platforms. Sensors are becoming lighter and cheaper and the use of modules and open architecture is making it easier to replace sensors as new technology becomes available. New technology such as hyperspectral sensors could provide the Armed Forces with entirely new capabilities and make it very difficult for enemies to camouflage themselves.

Artificial intelligence, machine learning and big data are experiencing very rapid development and this development will be highly relevant across all sectors in the Armed Forces. Artificial intelligence is about getting machines to perform tasks, which normally require human intelligence, such as interpreting speech, translating between languages or recognising objects in images. The advances taking place in artificial intelligence are largely due to the access we have had to large volumes of good data, which are used to train the machines, and access to machines that are fast enough. Applications will include establishing superior situational awareness and providing a more robust basis for rapid, sound decisions.

Large sums are being invested in **autonomous systems** in both civilian and military fields. This technology is progressing towards concepts in which autonomous systems and people complement each other. Military applications could include surveillance, reconnaissance, transport assignments and logistics, but also swarms of armed, unmanned systems. Mine clearance and replenishing logistics and ammunition during operations are examples of demanding and risky tasks that can be accomplished faster, better and with less risk by using unmanned systems. However, developments in artificial intelligence and autonomous systems raise legal and ethical questions about the extent to which systems should be allowed to make their own decisions.

There is a high rate of development in the fields of chemistry and biotechnology, particularly in **synthetic biology**. Ground breaking technology is being developed in several specialised fields. These developments are resulting in access to new, advanced materials, making it possible to operate in environments with extreme temperatures or to have low signatures that improve survival capacity. Most of the progress in chemistry and biotechnology will be of benefit to society. But these technologies can also be misused. The threat from new generations of chemical and biological weapons emphasises the importance of an effective understanding of the CBRN threat and of improving protective measures under the umbrella of Comprehensive Defence.

Technologies that convert **energy** from one form into another provide us with new ways to utilise energy. We are also beginning to see new ways to collect and store energy, including next-generation batteries and fuel cells. Functions currently only found on large platforms can also be used on small units such as armoured and unmanned vehicles, in self-sufficient autonomous systems that can operate in demanding and remote environments or by providing a more ready energy supply to high-energy weapons.

When different technologies work together and reinforce one another, this can fundamentally change future operations. Examples of grouped technology fields we believe will have this kind of effect in the future are **artificial intelligence, big data, autonomy and sensors.** There is a

major potential for innovation and radical change in the interaction between these technologies. This type of progress will add major value to a number of defence activities, from optimising the performance of military equipment to reducing costs and improving methods of conducting military operations.

Figure 4.1 Norwegian Defence Material Agency tests satellites north of Svalbard. (Photo: Simen Rudi / Norwegian Armed Forces)

5 The Armed Forces should improve the speed at which they use of existing and new technology

Technology is developing at an ever-increasing speed and, if the Armed Forces are to keep up, they must be able to adopt new technology more quickly, whether in response to a new problem or a new opportunity. In addition to the new technology being developed, innovation is also helping us to adopt and utilise existing technology in new ways. Both courses of development are important in terms of ensuring that the Armed Forces are effective and relevant. Technology fields can mature at highly variable speeds. It is also important to be aware of the fields in which developments are more gradual. Progress here will not result in fundamental changes in the short term but, in combination and over time, they could still have major consequences for operational capabilities.

Although military research centres and the defence industry will still be the most important players investing in the relevant R&D, an increasing proportion of this activity will take place outside what are currently the established organisations. At present, it is the civil sector that spends the most on technological development, in contrast to the Cold War period, but investments are driven by the commercial market. This means that the incentives for civilian and global technology companies will not necessarily coincide with societal security needs. State participation will therefore be a key factor in the development of technology for military purposes. This applies particularly to complex and expensive weapons platforms, in which a range of different weapons and sensor systems are integrated in the same platform. At the same time, much of the civil R&D activities tend to build on the more significant and fundamental R&D efforts aimed at military needs. The one does not exclude the other.

In the future, much of the Armed Forces' investments will be tied up with specific projects with a long-term horizon. This makes it more difficult to respond quickly to new needs. There is also little formalised experience in this sector with the rapid introduction of new technology. This applies to cooperation with industry, the procurement process itself and the ability of the Armed Forces to quickly introduce new operational concepts enabled by new technology. Traditionally, a great deal of time and resources have been spent developing specific requirements for the technology to be delivered in the future. Structural plans, which are products of long-term plans, should to a greater degree describe 'capabilities' that would provide leeway and allow the parties to look into alternative solutions and introduce new technology. Funds should be allocated for innovation processes in which the Armed Forces, researchers and the industry collaborate on experimenting with using existing technology in a range of operational contexts. This could improve the speed at which relevant and mature technology is applied in existing operational concepts and identify needs for further long-term research and development. This kind of collaboration would also give the industry greater insight into the Armed Forces' needs in the short and long-term and give the Armed Forces greater insight into what the industry is capable of delivering. Over time, this will ensure that new technological opportunities are better utilised. If technology is to be introduced successfully, it is important to have personnel with the right skills in technology, operational needs and the acquisition process.

The Armed Forces must also weigh up 'best possible' against 'good enough'. For example, this could include buying ready-made technology with defined specifications and using resources to adapt this technology to our needs, rather than developing completely new technology. It is important to have long-term R&D projects aimed at military technology and military systems. An important driver for this development should be operational needs. The sector must also have the ability to utilise technology developments being made in the civilian sector. That is why it is important to identify areas in which it is possible to adapt technology to improve its robustness and endurance for crisis and war situations.

Defence infrastructure is becoming increasingly expensive, partly because equipment is becoming more advanced. This makes it more difficult for small states like Norway to maintain complete, balanced and national military forces. A dramatic change in the relationship between price and performance could lead to a radical shift in the way military organisations are currently structured and operate.

6 More effective and relevant Armed Forces

Insight into technology developments and knowledge about how these affect defence policy, defence planning and the administration of the sector is therefore one of FFI's most important duties. In this report, we have summarised this insight in four recommendations:

1. We should prioritise the development of modern, high-tech Armed Forces.
2. We should remedy significant technological vulnerabilities.
3. We should make long-term investments in the most promising technology areas.
4. We should build a stronger culture of innovation in the Armed Forces.

Achieving these ambitions will help to give Norway a robust foundation for the development of effective and relevant Armed Forces.

About FFI

The Norwegian Defence Research Establishment (FFI) was founded 11th of April 1946. It is organised as an administrative agency subordinate to the Ministry of Defence.

FFI's MISSION

FFI is the prime institution responsible for defence related research in Norway. Its principal mission is to carry out research and development to meet the requirements of the Armed Forces. FFI has the role of chief adviser to the political and military leadership. In particular, the institute shall focus on aspects of the development in science and technology that can influence our security policy or defence planning.

FFI's VISION

FFI turns knowledge and ideas into an efficient defence.

FFI's CHARACTERISTICS

Creative, daring, broad-minded and responsible.

Om FFI

Forsvarets forskningsinstitutt ble etablert 11. april 1946. Instituttet er organisert som et forvaltningsorgan med særskilte fullmakter underlagt Forsvarsdepartementet.

FFIs FORMÅL

Forsvarets forskningsinstitutt er Forsvarets sentrale forskningsinstitusjon og har som formål å drive forskning og utvikling for Forsvarets behov. Videre er FFI rådgiver overfor Forsvarets strategiske ledelse. Spesielt skal instituttet følge opp trekk ved vitenskapelig og militærteknisk utvikling som kan påvirke forutsetningene for sikkerhetspolitikken eller forsvarsplanleggingen.

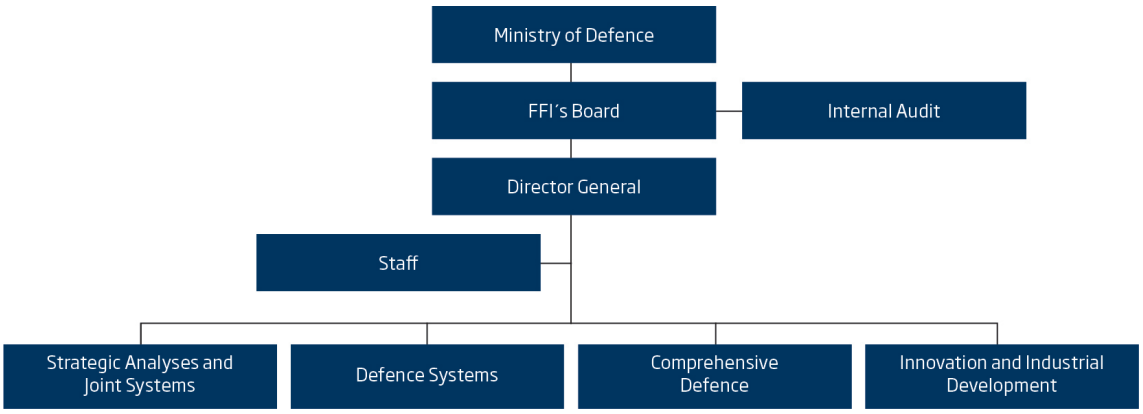
FFIs VISJON

FFI gjør kunnskap og ideer til et effektivt forsvar.

FFIs VERDIER

Skapende, drivende, vidsynt og ansvarlig.

FFI's organisation



Forsvarets forskningsinstitutt
Postboks 25
2027 Kjeller

Besøksadresse:
Instituttveien 20
2007 Kjeller

Telefon: 63 80 70 00
Telefaks: 63 80 71 15
Epost: ffi@ffi.no

Norwegian Defence Research Establishment (FFI)
P.O. Box 25
NO-2027 Kjeller

Office address:
Instituttveien 20
N-2007 Kjeller

Telephone: +47 63 80 70 00
Telefax: +47 63 80 71 15
Email: ffi@ffi.no

FFI Forsvarets forskningsinstitutt
Norwegian Defence Research Establishment