Servers Before Tanks?

Defence AI in Denmark

Andreas Graae

About the Defense AI Observatory

The Defense AI Observatory (DAIO) at the Helmut Schmidt University in Hamburg monitors and analyzes the use of artificial intelligence by armed forces. DAIO comprises three interrelated work streams:

- Culture, concept development, and organizational transformation in the context of military innovation
- Current and future conflict pictures, conflict dynamics, and operational experience, especially related to the use of emerging technologies
- Defense industrial dynamics with a particular focus on the impact of emerging technologies on the nature and character of techno-industrial ecosystems

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Design

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Content

1 Summary

Denmark is one of the most digitized societies in the world. The Danish defence and security sector is known for its technological advancements and commitment to innovation. Denmark is currently on the verge of pursuing defence AI through a range of emergent projects and initiatives. Moreover, the Danish armed forces are packed with advanced military technology that has the potential to collect large amounts of raw data with the help of radars and sensors.

The problem is, however, that data is not always used properly because it rarely leaves the frontline. Therefore, Danish Defence needs to adopt AI as a part of the development of a much stronger digital backbone to process the increasing amounts of information and share it across platforms, units, and domains. This is a prerequisite for integrating forces into synchronous, multi-domain operations; a goal Denmark is currently pursuing as a member of the NATO alliance.

Commenting on this strategic thinking, Danish Chief of Defence, Flemming Lentfer, has stated how he sees "a need for servers before fighter jets, ships and tanks,"[1] a viewpoint which is supported by several voices in the Danish defence and security environment. For instance, in the report Danish Security and Defence Towards 2035, the government's security policy analysis group notes how the "rapid technological development will require a significant technological boost to the Danish Armed Forces if it is to remain a relevant partner for our strongest allies."[2] However, the question of how exactly this technological boost should be accomplished and implemented into the organization remains uncertain and uncoordinated.

The purpose of this report is to look beyond the technicalities and provide an overview of the current development and use of military AI in Denmark from a broader socio-cultural point of view. Empirically, the report is informed by various sources (collected through field work, interviews, and more informal dialogues, workshops, meetings, and internal briefings) as well as desk research of written texts (some official and some not) which altogether offer an analytical framework for understanding the broader social and cultural approach to defence AI in Denmark.

First, it is important to understand the specific Danish strategic culture guiding the thinking and perception of defence AI. In Denmark, there has been a shift in

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1 "Forsvarschef: Behov for servere før flere kampfly, skibe og kampvogne."
2 Danish Security and Defense towards 2035, p. 5.

military strategy from expeditionary operations to territorial defence, including a renewed focus on Greenland and the Baltic Sea. Building military capacities in these regions has become a top priority in Danish security politics. And in this endeavour AI and big data algorithms will play a key role in processing increasing amounts of data and transform it into actionable intelligence and situational awareness for distant and inaccessible areas such as the Arctic. Several large players in the Danish defence industry are ready to contribute to developing such solutions.

However, the prospects of enabling AI to utilize data is somehow disconnected from the broader public perception of defence AI. In Denmark, the AI debate is often polarized and fluctuates between technological fetishism (hyping AI as a wonder tool that can solve all kinds of problems) and ethical caution. This overall ambivalence has resulted in a reluctance to formulate adequate political strategies and allocate the necessary resources to ensure a future AI-driven defence organization.

Consequently, Denmark lacks basic political guidelines and governance structures for the adoption of defence AI, which can ultimately become a problem in relation to international cooperation within NATO and with other strategic partners. The lack of political guidelines and strategic initiatives has raised critique, exposing a paradox inherent in the Danish defence AI imaginary: That is, the double ambition to be an AI frontrunner while at the same time restricting these ambitions for matters relating to security politics and ethics of defence AI.

The consequence of this schism is a hesitant and vacillating approach to defence AI in Denmark. Exploration and initial testing of AI systems is gradually taking place but is highly fragmented and isolated within silos in the organization. This results in doubling of effort and problems with sustaining the systems, which challenges a near-future integration of AI into C4ISR systems that can enhance decision making and situational awareness; all of which will ultimately be a precondition for the Danish armed forces to perform multi-domain operations in the future.

In sum, the path to adopt defence AI in Denmark is challenged by fragmentation and lack of governance and strategic vision. Whilst testing and evaluation of AI is starting to sprout from various branches of the organization, these initial efforts are mostly isolated and uncoordinated. The potential benefits in this bottom-up ap-

proach—such as explorative and experimental initiatives and a higher willingness to take risks—does not compensate for the lack of strategic direction.

An imperative task therefore remains in formulating a Danish strategy for defence AI with specific focus on where in the organization and how AI should contribute to the "technological boost" of the Danish Defence. This includes, first, a better or more precise definition of AI and what it should do for the military organization, operationally as well as in the support functions. Second, the recent paradigm shift, changed approach and establishment of public-private partnerships within the Danish defence industry and academia should be utilized to strengthen development of AI and AI-enabled software solutions in Denmark.

Finally, the need for testing, training evaluation as well as education of future defence AI specialist should be included and considered within the framework of existing and new military education programmes in Denmark. This is crucial to recruit and retain the right digital skills and competences needed for future Danish AI-enabled multi-domain operations and to build and sustain a modern data-driven defence organization.

2 Thinking About Defence AI

As a small nation, Denmark is still at an early stage on the path to adopting de-fence artificial intelligence (AI). Recognizing the increasingly central role AI plays in the global technology competition and on current battlefields, it has nevertheless become clear that Danish Defence needs a major technological boost to remain relevant for its allies.[3]

This not only provides new opportunities for the Armed Forces in Denmark, but also raises an array of questions and challenges of operational, organizational, strategic, ethical, and cultural character: How can a small state like Denmark take advantage of and make best use of its strengths in developing defence AI? What does an AI-based, data-driven defence organization look like? Does it make better sense to invest in software centres and data servers before tanks, jets, and ships? How will jobs differ from what we have been used to? And how to build trust in AI systems, data and algorithms while making the best decisions for the benefits of our warfighters?

Among these questions and challenges, selecting and procuring new military equipment is arguably the least complicated task. Rather, a successful Danish adaptation to defence AI requires a digital transformation of the culture and people in all levels of the organization—from warfighters and support staff working directly with software systems and interfaces on the battlefield to the commanders taking AI-based decisions in the headquarters and to the political and military leaders and managers who pave the way for a cultural change in the organization.

Accordingly, the Danish Ministry of Defence is about to launch a range of strategic initiatives on AI, data, and digitalization. These include setting a direction for a digital transformation of the organization and establish strong and robust connec-tions between operational and supporting processes, AI and data analysis, IT sup-port, and digital competence development among management and employees.

Supposedly, the upcoming strategic initiatives will address a major challenge in relation to AI in Danish Defence; that is, a growing gap between military and digital knowledge that is due to a general lack of AI literacy and understanding of how data can generate value for the organization. These challenges remain some of the greatest barriers for adopting defence AI, which makes conscription and recruitment of IT-specialists, technical translators, and experts in data science a still more demanding task. Thus, the challenge of cultivating a digital mindset for exploiting the possibilities of AI is becoming a top priority for Danish Defence.

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3 Danish Security and Defence towards 2035, p. 5.

In short, the people in the organization should learn to see data as a strategic asset that can provide tactical advantages and strategic autonomy for a small state like Denmark. And in this endeavour, it is key to prioritize education and enhance understanding of technology, digital literacy and trust in data, AI, and autonomous systems. But above all, and to succeed with the above, it remains pertinent to take into consideration the broader imagination about defence AI among employees and managers as well as the public debate among civil actors in academia and the industry.

2.1 Debating AI in Denmark

Fears and fascination have equally haunted the human imagination of artificial intelligence since the dawning era of computers and robotics. This is also the case in Denmark, where the discourses and imaginaries—like in most other Western countries—have been formed by popular culture and science fiction scenarios envisioning a future world of killer robots and super computers (like Skynet in Terminator or HAL in The Space Odyssey) turning against their human creators.

Although being arguably far from reality, such dystopic visions are still recurring themes in Danish media and public debate about future military AI in Denmark. For instance, the fictional video Slaughterbots created by the Campaign to Stop Killer Robots in 2018 is frequently featured in the Danish public debate and in campaigns warning against autonomous weapons.[4]

The Danish debate on defence AI was further accelerated by the wave of critical opinions about AI in relation to ChatGPT such as the critique stated by the Future of Life Institute in March 2023.[5] In an open letter, prominent voices such as Elon Musk called on all AI labs to immediately pause for at least 6 months the training of AI systems more powerful than GPT-4.

Inspired by this critique, Danish scientists and researchers made a similar state-ment in June 2023. In an open letter to the Danish Foreign Minister, Lars Løkke Rasmussen, the 20 researchers called for the Danish government to support an international ban on autonomous weapons systems. According to the researchers behind the letter, the Danish government should therefore develop a national policy for defence AI with the goal of a legally binding international agreement

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4 For more information, see: https://www.autonomevaaben.dk/ (last accessed 23 October 2023).
5 For more information, see: https://futureoflife.org/open-letter/pause-giant-ai-experiments/ (last accessed 23 October 2023).

that "prohibits the use of autonomous weapons which is not under meaningful human control or has humans as targets."[6]

The response from the Danish Foreign Minister was a rejection of any specific Danish policy, ban or legislation against autonomous weapons. However, he stated how he sees a "need for an international framework" and that Denmark together with other European countries supports a "two-step approach" to autonomous weapons where regulations according to international humanitarian law is central.[7]

2.2 Defining AI in Denmark

The open letter from the Danish researchers addresses a sensitive issue in the official Danish approach to defence AI: a general lack of governance and political guidelines on the matter. The rather vague response from the Foreign Minister is therefore symptomatic of the official Danish view on the more offensive aspects of defence AI; that is, to outsource such matters to international fora such as the United Nations.

Moreover, the AI debate in Denmark discloses a lack of conceptual clarity in the Danish political and public discourse about defence AI (and AI in general). This lack is mainly due a gap between the national level of ambition and the fact that no political or strategic guidelines have so far been formulated on defence AI in Denmark.

The Danish Agency for Digital Government describes AI as part of a wider national digital transformation and mentions examples of AI signature projects such as early cancer diagnostics, optimization of drinking water systems, and baggage logistics in Copenhagen Airport.[8] But it does not mention defence AI or aspects of AI in civilian education or research.

The only official strategy for AI is the Danish National Strategy for Artificial Intelligence that was launched in 2019. However, it does not at all touch upon military aspects of AI. The strategy defines AI relatively generically, and based on principles from the OECD and EU-commission, as:

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6 For more information, see: https://drive.google.com/file/d/1rm0R5YcSxU8Dj-d9meEjRzcgdcDXserO/view?pli=1 (last accessed 23 October 2023).
7 "Løkke afviser krav om dansk lovgivning mod dræberrobotter", Section 1.1.
8 For more information, see: https://digst.dk/digital-transformation/signaturprojekter/kunstig-intelligens/ (last accessed 23 October 2023).

systems based on algorithms (mathematical formulae) that, by analyzing and identifying patterns in data, can identify the most appropriate solution. Most of these systems perform specific tasks in limited areas, e.g., control, prediction and guidance. The technology can be designed to adapt its behavior by observing how the environment is influenced by previous actions.

Artificial intelligence is used in several areas, e.g., search engines, voice and image recognition, or to support drones and self-driving cars. Artificial intelligence can be a crucial element to increase productivity growth and to raise the standard of living in the years to come.[9]

There is, however, also a more fundamental distinction in the strategy, which is not fully encompassed in the definition above. This distinction is between general AI that refers to the full recreation of human cognition, and narrow AI, which involves reproducing specific aspects of cognitive abilities, such as image, video, and text recognition, data cleaning, structuring, sorting and various other types of analytical capabilities.[10]

Whereas the dystopic AI imaginary referred to in the section above would be possible only if general AI had been reached, it has become clear that various types of narrow AI based on machine learning and deep learning play an increasingly central role on the battlefield. These AI-based technologies enable the processing and analysis of data at a pace and scale far beyond what would be possible for human actors to grasp, and hence could shorten the observe-orient-decide-act (OODA) loop.[11]

Yet, the Danish debate surrounding defence AI is often polarized and fluctuates between technological fetishism (hyping AI as a wonder tool that can solve all kinds of problems) and ethical caution. This overall ambivalence has resulted in a reluctance to formulate adequate political strategies and allocate the necessary resources to ensure a future AI-driven defence organization. Consequently, Denmark lacks basic political guidelines and governance structures for the adoption of defence AI, which can ultimately become a problem in relation to international corporation within NATO and other strategic partners.

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9 National Strategy for Artificial Intelligence, p. 6.
10 Ibid.
11 Graae/Michelsen, „F-35, Skyborgs og den kommende svoerm," p. 129.

2.3 Denmark as AI "Front-Runner"

Although the Government's vision in the National Strategy for Artificial Intelligence is that "Denmark is to be a front-runner in responsible development and use of AI,"[12] one sector is entirely absent in the roadmap to achieving this frontrunner position: that of defence and security. Thus, the text is not at all specific about how the military should implement and use AI while being exposed to the battlefield's many dilemmas.

Instead, the strategy partly builds on ethical principles framed in the Declaration on AI in the Nordic-Baltic Region signed by the Ministers responsible for digital development from Denmark, Estonia, Finland, the Faroe Islands, Iceland, Latvia, Lithuania, Norway, Sweden, and the Åland Islands. In this declaration the countries agreed to collaborate to "develop and promote the use of artificial intelligence to serve humans."[13]

Moreover, the Danish AI strategy supports the declaration objectives for making the Nordic-Baltic region a digital leader and embraces the European Union Commission Communication on "Artificial Intelligence for Europe" and the declaration of 24 EU Member States and Norway on "Cooperation on Artificial Intelligence."

The strategy thus focuses mostly on the possibilities for AI to contribute to better public-sector services and growth in the business community. Moreover, it highlights how a safe and responsible use of AI should follow six ethical principles, which are to be incorporated in the development and use of artificial intelligence in order to "secure respect for individuals and their rights, and for democracy."[14]

The six ethical principles are:

1. Self-determination
2. Dignity
3. Responsibility
4. Explainability
5. Equality and justice
6. Development

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12 National Strategy for Artificial Intelligence, p. 5.
13 AI in the Nordic-Baltic Region, p. 1.
14 Ibid., p. 8.

Among the goals in the principle about dignity are, for instance, that "AI should not cause injury, it should support due process and it should not unjustifiably place people in a worse position," and moreover it is stated that "AI should not be used to infringe fundamental human rights."[15]

If these goals are to be taken literarily, it might seem unlikely that AI will be used in relation to power projection by Danish military anytime soon—and least of all in situations where AI-enabled warfighting power requires a legal and ethical mandate to actively and effectively cause harm, or threaten to cause harm, to humans.

The Danish ambitions for a responsible and explainable development and use of defence AI is aligned with international norms and standards such as the principles for safe and responsible use of AI in the NATO AI strategy.[16] Thus, Denmark adheres to the common notion that humans must remain in full and constant control and that AI must be hierarchically subordinated to humans. But unlike many other countries, Denmark has not yet formulated any specific (ethical, juridical, or political) guidelines for the development and use of defence AI—let alone decided on how it will use military technologies and systems based on AI.

This absence of political or strategic guidelines—or any substantial political debate on the subject at all—has been critiqued by military commentators and legal experts. For instance, it has been questioned how the Danish Airforce will in fact make proper use of the sophisticated AI technology built into newly procured platforms such as the F-35 fighter jets if it is to comply with the ethical principles formulated in the AI Strategy.[17]

This critique certainly exposes the paradox inherent in the Danish defence AI imaginary and the double ambition to be AI frontrunner while at the same time restricting these ambitions for matters relating to the security politics and ethics of defence AI.

Despite the absence of more specific political guidelines for military use of AI, digitalization and datafication is a rising priority for the Danish Armed Forces. Commenting on the political agreement of the defence budget for the coming period, the Danish Chief of Defence, Flemming Lentfer, stated what he sees "a need for servers before fighter jets, ships and tanks,"[18] thereby advising the politicians to invest in AI and data processing software before buying conventional weapons and military hardware such as tanks, ships, and aircrafts.

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15 Ibid., p. 28.
16 "NATO Artificial Intelligence Strategy."
17 See for example Dr. Iben Yde interviewed in: Jariner, "Militæret mangler klare rammer for brug af kunstig intelligens."
18 "Forsvarschef: Behov for servere før flere kampfly, skibe og kampvogne."

The statement provoked certain critical reactions among military analysts and commentators, arguing that data centres and AI do not compensate for the need for conventional military capacities and hardware.[19] In other words, the message from the critics seems to be that it does no good to have headquarters with splendid overviews and situational awareness if there are no units on the battlefield to react to it.

2.4 A Shift in Strategic Culture

It could seem as if the statement from the Chief of Defence marks a shift in strategic culture and procurement practice for the Danish Defence. This is not only because it comes from the highest-ranking military officer and commander in chief of the Danish Armed Forces. The statement seems to be aligned, too, with political initiatives coming from the Ministry of Defence as well as implementation of new and more agile procurement processes and practices in the Danish Defence Acquisition and Logistics Organization (DALO).

Traditionally, Denmark has invested its military capabilities mainly in weapons systems such as artillery and tanks procured from allied nations, for the most part through countertrade agreements and offset deals, which obliges the supplying company or the exporting country to reinvest some proportion of the contract in Danish products. In particular, Denmark has invested its major military purchases in platforms and capacities from American industries and manufacturers.

This, among other things, has to do with the strong bonds between Denmark and the US. Historically, the strategic culture and thinking in Denmark has been tied to the military principles and priorities of NATO and especially to the foreign policy of the USA. When Denmark in 2001 decided to participate in the war in Afghanistan just three months after the terrorist attacks 11 September 2001, it was thus an act of solidarity with the United States.[20] Already in the 1990s, the Danish military engagement in Kosovo marked a new form of military activism that broke with the more "defencist" passivity that marked the Danish security politics and discourse in the late 1970s and 1980s. This also included a new focus on European integration and globalization, which meant that military power was understood in a new way in Denmark.

The transformation of the Danish strategic thinking towards a culture of activism and cosmopolitism has naturally reached a new peak with the Russian invasion of

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19 "Militærforsker til forsvarschef: Datacentre opvejer ikke behovet for mere militært isenkram."
20   Rasmussen, "What's the Use of It?': Danish Strategic Culture and the Utility of Armed Force," p. 67.

Ukraine and the following Danish donation politics of military equipment and capacities. This includes tanks and F-16 fighter jets. But also—and more interestingly for in a defence AI context—capacities for intelligence, surveillance and reconnaissance such as drones equipped with AI-enabled sensor and software systems has been produced and delivered from Danish companies such as Nordic Wing and Skywatch in 2022 and 2023.[21]

The latter even got help in promoting their RQ-35 Heidrun drones from the former Star Wars actor Mark Hamill (Luke Skywalker) as part of a project crowd-funding drones for Ukraine.[22] This emphasizes the role of media, public perception and the broader cultural drone and AI imaginary in promoting new military technologies for the battlefields.

Moreover, the new world situation and the threat from Russia also means that the Arctic region has gained renewed attention in Danish security politics. The renewed Danish focus on the Arctic is largely motivated by both NATO and the US who have steadily required Denmark to improve the surveillance and defence of its own territory, including Greenland and the Faeroe Islands. There is a growing concern over the so-called GIUK-gap that forms a naval choke point: the two stretches of ocean between Greenland, Iceland, and the United Kingdom.

In 2021, this increased international pressure resulted in a political Agreement on Arctic Capacities[23] that included acquisitions for DKK1.5bn in surveillance and communication capacities. This included air surveillance radars, coastal radars, space-based surveillance and satellite communication, drones, etc. Naturally, the purpose of all these investments in new Arctic surveillance capacities is to gather huge amounts of information and data that needs to be processed to become meaningful, actionable intelligence.

However, the spending on Intelligence Processing and Analysis only makes up a small part in the agreement, which indicates another challenge in the Danish military and strategic culture: namely, that hardware capacities are often prioritized above software and data processing solutions. This reveals a need for more efficient data management and software systems, allowing for better utilization of the gathered data, e.g., for dark target detection etc. It is therefore important to discuss whether Danish AI solutions should be developed or whether Denmark should look elsewhere and use already developed solutions to manage the growing amounts of data.

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21 For more information, see: https://www.dr.dk/nyheder/indland/efterspoergsel-paa-droner-til-ukraine-giver-vokse-vaerk-til-dansk-selskab (last accessed 23 October 2023).
22 For more information, see: https://sky-watch.com/news/the-rq-35-heidrun-drone-has-been-funded-via-the-air-alert-app/ (last accessed 23 October 2023).
23 Agreement on Arctic Capacities, 2021, p. 1.

In fact, several players in the Danish defence industry are ready to contribute to developing such solutions, which has already been explored through workshops and exercises. One example is the ArcticX exercise that was held in 2021 and repeated in 2022 in the H.C Andersen Airport outside of the Danish city Odense. Here, the consortium IRSA (Integrated Remote Sensing in the Arctic) Development Group demonstrated how various sources of intelligence (based on sensor data from drones, satellite imagery, etc.) could be fused and integrated into a joint common operating picture (JCOP). Through use-cases and live demonstrations, the exercise showed how AI (Machine Learning and Deep Learning algorithms) could be used for dark target detection, fishing control, identification and tracking of icebergs, oil slippage, etc.. However, there is also here a tendency to valorize platforms and capacities (such as sensors, satellites, and remotely piloted aircrafts) over software and the "invisible" systems that is supposed to integrate the gathered data.

This discussion is becoming still more pertinent with recent procurements of advanced and extremely expensive capabilities for the Danish Airforce—such as several Seahawk helicopters and F-35 fighter jets. This is why the forthcoming strategic initiatives for a future digitalized Danish Defence allegedly aim to ensure coherence between operational and supporting areas, including the management of data.

This is crucial if Denmark is to get to optimal output from new digital technologies and improve situational awareness on the battlefield as well as increase the speed of decisions, information sharing and communications in general. In short, the Danish Defence's operational and administrative data as well as digital networks are critical to defence operations.

3 Developing Defence AI

In the pursuit of a digital transformation of the organization, Danish defence has engaged in several research and development projects and activities related to AI. These involve partnerships with research institutions, collaboration with industry partners, focusing on developing AI algorithms, data analysis techniques, autonomous systems, and other AI-enabled technologies that can enhance military capabilities.

However, gaining insight into new military technology more generally through research and development in the organization has long been downgraded by broader political agreements and alternative military focus areas. In contrasts to both Norway and Sweden's extensive military R&D capabilities, the Danish Defence R&D primarily has a function of supporting the acquisition of new capabilities.

As a result, the internal R&D of Danish Defence has been cut several times over the past 20 years while having been relocated from the services and centralized into the Defence Command under the Plan and Capabilities Division. Currently, Denmark spends less than 0.5 percent of its defence budget on research and development, while other countries in the EU spend around 1.7 percent of theirs on research.[24]

What research remains today only conducts independent R&D to a very limited extent and instead functions as a connecting link in the network. This creates access to, among other things, the knowledge of allied cooperation partners and new partnerships with the defence industry.[25]

3.1 Defence AI in Public-Private Partnerships

In the latest defence agreement for the period 2018–2023, research and development nevertheless received renewed political attention. The agreement states that: "The defence cooperation with industry on R&D is strengthened, among other things with a view to maintaining the Danish defence industry as an attractive partner for other countries' defence industries."[26]

This trend is further strengthened with the political agreement for the coming period (2024–2033). The Government and a broad majority of the Danish Parliament have agreed that Denmark shall reach two percent of the Gross Domestic Product (GDP) on defence no later than 2030. The agreement entails investments

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24 "Forsvarsudspil sikrer forskning i nye teknologier."
25 Breitenbauch/Mathiesen, Militaerteknologisk situationsfostaelse, p. 20.
26 Danish Defence Agreement 2018–2023, p. 11.

in Danish security and defence amounting to app. DKK143bn (more than €19bn) during the period 2024–2033. The government also plans to strengthen research and development in new defence and security technologies, including drone and quantum technology.[27]

Moreover, in 2021 the Danish Government released a capstone document on the subject, the National Defence Industrial Strategy. A central element in the strategy is the realization that "the Danish defence industry is essential for Denmark's national security and our joint efforts with allies and partners."[28]

In short, Denmark finds itself in a changed and more complex threat landscape in which an increased great power competition is particularly pronounced in a long-term race for the development of new civil and military technology—such as the AI arms race between USA and China.[29]

The Danish AI R&D takes place in the private sector where technologies with commercial aims are merged into the military world. The strategy therefore articulates the need for stronger collaboration between the public sector, the Danish research institutes, and the defence industry. It also calls for better utilization of the potential that exists in small and medium-sized companies and in innovation and start-ups sprouting from the research environment at universities.

With the intent of strengthening the cooperation for Danish security, the strategy thus invites both the industry and academia to collaborate closely regarding defence AI research and development through new civil-military partnerships and a bolstered AI ecosystem.

3.2 The Danish AI Ecosystem

The Danish AI ecosystem consists of various organizations, initiatives, and stakeholders involved in the development, promotion, and application of defence AI. Denmark has been actively fostering its AI ecosystem to drive innovation, economic growth, and societal progress, which has been further strengthened by the National Defence Industrial Strategy mentioned above.

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27 Aftale om dansk forsvar og sikkerhed 2024–2033, p. 10.
28 National Defence Industrial Strategy, p. 5.
29 Breitenbauch/Mathiesen, Militaerteknologisk situationsfostaelse, p. 20.

The strategy specifically mentions AI as an area of focus: "The Government prioritizes providing scope for collaboration with companies regarding disruptive technologies, including artificial intelligence."[30]

Central to the AI ecosystem and the Government's strategy are public-private partnerships and civil-military enterprises. This collaboration is based on the triple helix innovation theory, which emphasizes the importance of interaction between the public sector, industry, and universities (Table 1).

For instance, the strategy states how "innovation and new partnerships are necessary to ensure that defence authorities and Denmark's defence industry are ready to meet the future."[31] In other words, it is crucial for the realization of the strategy that Defence is brought closer to collaboration partners from industry and Danish research institutes.

Table 1: **Actors of the Danish Defence AI Ecosystem**

Defence	Academia	Industry

• Ministry of Defence (MoD)
• Danish Ministry of Defence Acquisition and Logistics Organisation (DALO)
• Danish Defence Research Centre (Værnsfælles Videnscenter), DALO
• Cyber Division, DALO
• Defence Command
• Plans and Capabilities Division
• Chief of Defence's development forum
	• The National Defence Technology Centre (NFC)
	• Niels Bohr Institute (NATO DIANA project), University of Copenhagen
	• Pioneer Centre for AI (P1)
	• IT University of Copenhagen
	• The Technical University of Denmark (DTU)
	• The Alexandra Institute
		• AI4DEF
		• TERMA A/S
		• Systematic (Sitaware Suite)
		• Weibel
		• SAP/SAS
		• Startups:
		  • Robotto
		  • Trifork
		  • Skywatch
		  • Nordic Wing

Source: Authors

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30 Ibid, p. 9.
31 Ibid, p. 20.

SERVERS BEFORE TANKS?

Defence

In the Danish defence organization, research and development of defence AI is formed roughly through the so-called "Bermuda Triangle" between the Danish Ministry of Defence (MoD), the Defence Acquisition and Logistics Organisation (DALO) and the Defence Command. The annual briefing for the Defence Command describes, for instance, how the Chief of Defence Development Forum is used as an arena for discussions of new trends and opportunities across types of weapons and defence. The declared goal is to strengthen the Armed Forces by challenging conventional solution models by applying new insights and flows (such as IT as a "force multiplier," including AI).

In addition, DALO is responsible for procurement, supply, maintenance, development and decommission of material capabilities, IT and services for the Danish armed forces and Emergency Agency. With the slogan "Open for Business," DALO (and the Danish MoD, which launched it as a strategy in 2013) wish to signal openness and to support Danish industry and export, not least in the growing field of AI research and development.[32]

The Danish Defence Research Centre (Værnsfælles Videnscenter) supports DALO in research and development, trend analysis and technology scouting for current and future investments in military acquisitions, in particular on AI technology and other emerging and disruptive technologies (EDT). Moreover, the Danish Defence Research Centre co-finances research and development projects carried out in collaboration with Danish companies and research institutions.

In other words, the Danish defence uses co-financing projects to expand research capacity in several areas where it does not have the necessary resources at hand (due to the aforementioned cuts on research and development). The purpose of the projects is partly to support the defence industry and partly to provide DALO with important technological knowledge for the benefit of the Armed Forces' operations. These co-financing opportunities have become increasingly popular, especially after a stronger connection to the European Defence Fund (EDF) had been established.

A core element in the National Defence Industrial Strategy is to accelerate "speed, flexibility, transparency and enhanced triple-helix collaboration" as important parameters for this modernized acquisition practice.[33]

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32 Open for Business.
33 Ibid, p. 13.

The strengthened civil-military cooperation and partnerships can be regarded as a significant paradigm shift in Danish military strategic culture. While several of Denmark's allies, e.g., the Netherlands, France, and Norway, traditionally feature close ties between defence authorities and defence industries, the Danish Ministry of Defence and its agencies have historically been more reluctant to enter into collaborations with the Danish defence industry.

Among other things, this is rooted in the earlier mentioned historic Danish "defencist" way of thinking about military power in which private defence industry actors traditionally have not been invited into the governmental decision circles. It is therefore largely uncharted waters when the Armed Forces now enter various partnerships about AI with industry and research institutes.

Academia

Danish universities and research institutions play a crucial role in advancing AI knowledge and expertise. Institutions like the Technical University of Denmark (DTU), Aalborg University, University of Southern Denmark and the University of Copenhagen have research groups and programs dedicated to AI and machine learning. These institutions collaborate with industry partners and contribute to cutting-edge research.

In particular, areas such as AI, big data, and quantum technology are targeted. At the same time, Danish research institutions are world-leading in select areas of space and military technology. This research can support Denmark's national security by converting new knowledge into innovation in Danish companies and into solutions for Denmark's operational entities.

For instance, the Technical University of Denmark (DTU) has extensive research in applications of AI for security purposes. And in 2022, NATO located a quantum research centre at the University of Copenhagen's Niels Bohr Institute as part of the Defence Innovation Accelerator for the North Atlantic (DIANA). [34] Another quantum technology test centre is placed at DTU to develop and manufacture quantum technological solutions. Among other things, the centre develops quantum sensors and ultra-fast quantum encryption devices that can prevent hacking.[35]

In 2023, the University of Copenhagen collaborated with the IT University of Copenhagen and other Danish universities to establish a Pioneer Centre for AI (P1). Also in 2023, the eight Danish universities and five government-approved technical service institutions (GTS) formed a joint National Defence Technology Centre

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34 Danish Security and Defence towards 2035, p. 18.
35 For more information, see: https://security.dtu.dk/ (last accessed 23 October 2023).

(Nationalt Forsvarsteknologisk Center, NFC) to increase collaboration with industry and the Danish Armed Forces.

Among the approved technical service institutions participating in the National Defence Technology Centre is, for instance, the Alexandra Institute whose AI and Analytics Lab and Visual Computing Lab is one of the biggest commercially available providers of AI research and development in Denmark.

The purpose of the National Defence Technology Centre is to contribute to a critical technological boost of the Danish Armed Forces and the Danish defence industry through interdisciplinary partnerships. It utilizes Denmark's strengths in AI and similar areas such as space, quantum, cyber security, green fuels, autonomous systems etc.

Industry

In recent years, Danish private commercial entities – including companies such as TERMA, Systematic and Weibel – have actively explored the potential of AI in military applications to address various defence challenges and build partnerships with the Danish armed forces and academia. These companies focus on leveraging AI technologies to enhance the capabilities of armed forces, improve efficiency, and contribute to national security.

The Danish private commercial industry's engagement in AI for the military is overall enthusiastic and encompasses a wide range of areas. One notable aspect is the development of autonomous systems, including unmanned aerial vehicles (UAVs) and ground vehicles. These autonomous platforms equipped with AI algorithms offer advanced reconnaissance, surveillance, and logistics capabilities.

Moreover, Danish companies specializing in defence AI have been at the forefront of developing intelligent data analysis tools and predictive analytics models for battle-management and command and control purposes. These technologies aid in processing vast amounts of data, extracting actionable insights, and supporting informed decision-making in real-time operational scenarios.

A significant, although paradoxical, example is the development of the F-35 fighter jet. For years, Danish defence companies such as TERMA have played a key role in the development and production of highly specialized AI-based software and sensor solutions for this fifth-generation fighter aircraft.[36] Yet, as discussed in the previous chapter, the lack of an overarching Danish IT and data infrastructure

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36 National Defence Industrial Strategy, p. 7.

has made critics doubt how the Danish defence organization is at all geared to make proper use of all the gathered data and sophisticated technologies built into the F-35 jets.

Another crucial aspect of Denmark's private industry's involvement in AI for the military is cyber security. As the digitization and interconnectivity of military systems increase, the need for robust cyber defence measures becomes paramount. Here Danish companies specializing in AI develop advanced cybersecurity solutions that employ machine learning algorithms to detect and mitigate cyber threats effectively.

3.3 Current R&D Projects on Defence AI

In 2023, TERMA, the country's biggest defence company, set new standards for military R&D in Denmark by signing a 30-year contract with Danish Defence for delivering an air defence system to the Danish Army's 1st Brigade and thereby meeting NATO's capability goals for Denmark in the area of Very Short-Range Air Defence (VSHORAD).[37]

With the agreement, TERMA becomes the responsible systems integrator for Danish air defence. This means that the company must integrate all the system's sub-elements and ensure that future air defence capabilities can form an integral part of the brigade's operations in the overall air defence. This includes being able to communicate and exchange data with other air defence systems. The system will be based on TERMA's AI-assisted command and control system (C2), which, among other things, can connect several units via integration with various sensors and communication systems.[38]

Another significant example of a current AI project and international partnership is the AI for Defence project (AI4DEF) consisting of 22 partners (companies and research institutions, including Aalborg University) from 10 countries of which TERMA is the consortium lead.

The project is set to "pave the way for accelerated development and application of AI in defence in order to maintain European sovereignty and excellence in this area" and is backed and funded by the European Commission as a part of the

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37 "TERMA signs framework agreement with Danish defence on system integration and maintenance for integrated air and missile defence system."
38 Ibid.

European Defence Industrial Development Programme (EDIDP).[39] In particular two functional areas will supposedly be studied, designed and tested in the AI4DEF project, namely "situational awareness / decision-making" and "planning optimization."

For instance, AI4DEF has demonstrated how AI can help human operators exploit the increasing amounts of data from various sources to support operational planning through modelling and simulation. One case of interest could be unmanned aerial vehicles (UAV) where AI can be used for ISR missions through automatization and optimization of route planning and processing of unequalized data from a range of sensors and sources, e.g., satellite imagery, weather data, open source intelligence, etc.

Several other R&D projects on defence AI have been co-financed by DALO. One example is a project that has prototyped and tested AI-based technologies for automated terrain analysis. Also, the Defence Command has run an experimental project on defence AI in collaboration with DALO. The project focused on testing and development of software using AI/Machine Learning to classify aircrafts based on radar data.[40]

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39 For more on this project, see https://ai4def.com/ (last accessed 23 October 2023). The TERMA-led project also includes Alborg University, Airbus (France and Germany), Arctur (Slovenia), Data Machine Intelligence (Germany), DefSecIntel (Estonia), e-GEOS (Italy), Eight Bells (Cyprus), Elsis PRO (Lithuania), Eurodecision (France), FlySight (Italy), GMV (Spain), International Astronautical Federation (France), Lake Fusion Technologies (Germany), Leonardo (Italy), Numalis (France), MBDA (France, Germany, Italy), Tilde (Latvia), and the University of the Bundeswehr (Germany).
40 Årsberetning for Forsvarskommandoen 2022. pp. 8–9.

4 Organizing Defence AI

In Denmark, the lack of an overall organizational approach to defence AI is countered by upcoming strategic initiatives (mainly coming from the MoD) and a joint dialogue among different branches of the Danish Armed Forces, the Ministry of Defence, the Cyber Division (part of DALO), the Defence Command, and other relevant stakeholders. The primary objective is to leverage AI technologies to enhance the efficiency, effectiveness, and safety of defence operations.

Only recently, Denmark has started to reorganize and adjust the organizational structure for a better adoption of defence AI. The formation of the above-mentioned Cyber Division in 2023 remains central to the development of the organization's overall IT architecture and communication infrastructure.

At the organizational level, it is therefore crucial for the overall readiness and maturity of the organization to develop a so-called "digital backbone" for the defence collaboration and information sharing among the different services and stakeholders to ensure a cohesive approach to defence AI in Denmark.

While it has not yet been specified what this "digital backbone" should in fact include, it has become clear that it is not primarily a technical solution or system but rather a concept, including not only technology or data, but also people and processes.

4.1 Joint Approaches

At the ministerial level, a forthcoming capstone document on digitalization will allegedly be decisive in setting a direction for the digital transformation of the organization. The actual organizational changes that result from the digitalization strategy are expected to take place gradually and iteratively during the period from 2024 to 2029. In this regard, it is important to develop an open and agile mindset that allows for testing of AI-driven initiatives (or within other emerging and disruptive technologies, EDT), which can be shut down ("fail fast") if they do not provide the desired value.

Moreover, the forthcoming strategic initiatives and capstone documents will supposedly have a strong focus on data exploitation including the future users of digital technologies and AI systems as well as the design of user-friendly and intuitive AI-driven solutions. In short, the users must be involved through user development and implementation and by using agile methods.

Preparing the organization, including its people and culture, for the successful adaptation of defence AI, the Danish Ministry of Defence also participated in

international fora and working groups, including the British-American initiative AI Partnership for Defence (AIPfD). Besides partaking in seminars and meetings in the partnership, Denmark also contributed to a sub-working group with the aim of developing an AI Readiness Model. In particular, Denmark contributed to the readiness framework with one out of the eight building blocks, which can be used to measure the AI readiness in the defence organizations: namely that of Culture and Organization.

4.2 Single Service Approaches

The Danish Armed Forces aim to integrate AI into various aspects of their operations. The individual services within the Danish Armed Forces, such as the Army, Navy and Air Force, have their own specific initiatives and applications for AI.

While the Army focuses on using AI for autonomous systems such as drones and other unmanned aerial or ground vehicles (UXVs) or intelligent logistics systems, the Navy explores AI-driven systems for maritime surveillance and autonomous underwater vehicles.[41] Also, the air defence systems integrated on the Danish frigates such as CIWS (close-in-weapons-systems) and the newly procured SM2 air defence missiles are examples of AI-based systems incorporated into military technologies.[42]

The Air Force leverages AI for tasks such as aircraft maintenance (e.g., predictive maintenance), mission planning, air traffic management and command and control—all of which are absolutely necessary for organizing and operating the newly procured F-35 fighter jets.

In addition, the Danish Emergency Management Agency (DEMA) under the Ministry of Defence is already using AI-enabled systems for pattern analysis based on drone imagery in emergency operations and for search and rescue (SAR). Moreover, DEMA has strengthened its digital support and integration with international and national partners, such as the municipal emergency services and the police.

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41 For more information, see: https://www.fmi.dk/da/nyheder/2021/nye-autonome-undervandsdroner/ (last accessed 23 October 2023).
42 For more information, see: https://www.navalnews.com/naval-news/2022/05/danish-navy-installs-sm-2-missiles-niels-juel/ (last accessed 23 October 2023).

4.3 Building an AI-Driven, Data-Centric Organization

For several years, the Danish defence has worked on a common data and information infrastructure, now called the Danish Common Operational Information Environment (DACOIE). The concept is supposed to provide the basis for an operative and data-based overview that strengthens the ability to make faster and better decisions and communicate them across defence organizational units.

While there has been some initial dispute concerning whether DACOIE should be regarded as a technical system or more of an idea or concept, the latter approach now seems to dominate. Thus, DACOIE should not be understood as a concrete technology, but as a conceptual idea; a direction for how to build a digital backbone for the organization that enables the Danish armed forces to operate digitally and integrated across all five domains (land, sea, air, cyber and space), and allows live data to be exchanged between domains and units.

The incentive behind DACOIE is also based on needs and demands from Denmark's allied and collaboration partners, most importantly NATO, the US, and the UK. For a while, the conceptual discussions in the Alliance have focused on digital transformation to secure its position in the future. This includes converting its data usage to cloud-based solutions, where AI-enabled data analysis remains central as a basis for decision-making that outperforms that of our adversaries. The construction of a digital platform (Defence Information Cloud, DEFIC) is thus a prerequisite for this collaboration. And this is probably why DACOIE has become a prestige project for Danish defence—which gives the words from the Danish Chief of Defence about "servers before tanks" another dimension.

5 Funding Defence AI

With the Danish defence agreement for 2024–2033, the Government and a broad majority of the Danish Parliament agreed that Denmark shall reach two percent of GDP for defence no later than 2030. The agreement entails investments in Danish security and defence amounting to approx. DKK143bn (more than €19bn) during the period 2024–2033.

The government also plans to strengthen research and development in new defence and security technologies, including not only drone and quantum technology but also development of defence AI. As discussed in chapter 3.1, this is a continuation of the latest defence agreement for the period 2018–2023, in which research and development received renewed political attention. As a rough assessment of the spendings on digitalization and defence AI, the defence budget for 2018–2023 contained a range of new initiatives, including spendings on cyber and IT security for DKK567m (€76m).

The Danish government supports research and innovation projects related to AI and defence technologies. Some of the relevant funding programs in Denmark[43] include:

- **Innovation Fund Denmark:** This is a major public funding body that supports research, development, and innovation projects across various sectors. They provide funding for collaborative projects involving universities, research institutions, and companies working on defence-related technologies.

- **The Danish Defence Acquisition and Logistics Organization (DALO):** DALO is responsible for procurement and logistics in Danish Defence. They occasionally fund projects related to defence research and development, including those involving AI applications.

- **The Danish Council for Research and Innovation Policy:** The objective of the council is to further the development of Danish research, technology, and innovation for the benefit of society.

Moreover, Denmark has a growing technology sector and an active venture capital ecosystem that supports various industries, including defence and AI. The Danish Government has launched a range of initiatives to strengthen the national AI ecosystem, which could also benefit the development of defence AI. Examples include the extensive funding programs on quantum technology to boost computing power.

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43 In addition to the national funding programs, Denmark participates in the European Union's Horizon Europe research and innovation framework program. Danish private sector and Danish defence companies are involved in several European research and development projects and consortia through the EDF.

Some prominent venture capital firms and investors in Denmark that have shown interest in AI technology and defence-related sectors include:

- **Denmark's Export and Investment Fund (EIFO) (previously Vækstfonden):** EIFO is Denmark's state investment fund that provides capital and expertise to innovative Danish companies, including those in the technology and defence sectors.[44]

- **AI Denmark:** AI Denmark supports Danish small and medium-sized companies (SME) in the use of artificial intelligence and data-driven business development. Its vision is to make Denmark a pioneering country in business-oriented utilization of responsible artificial intelligence.[45]

- **Nordic Eye Venture Capital:** Nordic Eye is an early-stage venture capital firm focusing on technology companies in the Nordic region, including those involved in AI and defence-related technologies.[46]

- **Northzone:** Northzone is a leading European venture capital firm that invests in technology start-ups across various sectors, including AI and defence technologies.[47]

44 For more information, see: https://www.eifo.dk/en/ (last accessed 23 October 2023).
45 For more information, see: https://aidenmark.dk (last accessed 23 October 2023).
46 For more information, see: https://nordiceye.com/ (last accessed 23 October 2023).
47 For more information, see: https://northzone.com/ (last accessed 23 October 2023).

6 Fielding and Operating Defence AI

Defence AI will be central to future Danish operations as part of an information environment where the right information is available to the right people, in the right format, at the right time.

As mentioned earlier, the newly established DACOIE concept aims to improve the organization's communication infrastructure and ability to process data and information to use AI to achieve battlespace advantage and connect sensors to decision-makers and effectors (supporting the understand-decide-act functions).

Danish defence is already working with AI-enabled command and control (C2) solutions. This includes, for instance, the SitaWare Suite[48] developed by the Danish company Systematic, which is used by the Danish Army as the preferred battle management system. SitaWare uses artificial intelligence to create situational awareness and to support military leaders in decision-making on the battlefield.

Systematic's latest add-on to the suite, SitaWare Insight, further increases the use of AI for detection of anomalies with algorithms trained for detecting and assessing deviations from the common operating picture. However, the add-on has not yet been purchased by the Danish Defence, which means that the armed forces are still missing the AI-driven software to make proper use of the increasing amounts of data and information made available on the battlefield.

6.1 The Current Impact of AI

As discussed above, the discourses, narratives and imaginaries surrounding defence AI in Denmark—whether it is ethical principles in the National AI strategy or simply a lack of AI literacy and digital skills among the people in the organization—can make it hard to imagine how AI will or can actually be used in Danish defence. Yet, automation and AI-assisted solutions are already enrolled to some degree in the organization for a number of different purposes, as discussed below.

Administration and Logistics

Administrative robots, or RPAs (Robotic Process Automation), have been used by the Danish defence since 2019 where they were created by the Robotics Operational Centre, which is part of DALO. The software was developed to automate administrative tasks, so that the employees of the armed forces have more time for core tasks.

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48 For more information, see: https://www.systematicinc.com/products/n/sitaware/ (last accessed 23 October 2023).

Feedback from the employees has indicated that using AI for the automation of workflow can make a big difference. Not least on one of the busiest administration days of the year in the Danish defence, namely the conscription day for the Army. Here, the robots handle large amounts of data and ensure that the conscripts are quickly registered in the Defence systems.[49]

The enrolment of administrative RPA robots for handling conscription data is expected to inspire several other administration and logistics functions in the organization. [50]

C4ISR

Various AI-based types of decision support in Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems are currently used by Danish defence. Systems such as the SitaWare suite by Systematic and the JIMAPS from TERMA[51] incorporates various AI techniques and technologies to enhance the situational awareness of military commanders and decision-makers.

For instance, AI algorithms are used to integrate and fuse data from multiple sources such as sensors, surveillance systems, satellites, and intelligence databases. The use of AI for such purposes will assumably be more broadly implemented if or when system add-ons (like SitaWare Insight) or a common data and information infrastructure is rolled out. This will also enable other AI techniques like data mining, pattern recognition, and machine learning to identify relevant information, filter out noise, and provide a comprehensive view of the operational environment.

Unmanned and Autonomous Systems

In recent years, the Danish military has started using unmanned systems in a tactical capacity for tasks like reconnaissance and surveillance, target recognition, route planning, autonomous navigation, and mission execution.

AI is increasingly incorporated into these unmanned or autonomous systems that enable effective coordination and collaboration between human operators and autonomous systems, enhancing overall C4ISR capabilities.

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49 FMI støtter Hæren med ny robot.
50 Ibid.
51 For more information, see: https://www.terma.com/products/multi-domain/jimaps/ (last accessed 23 October 2023).

Cyber Security

As mentioned, Denmark is one of the most digitized societies in the world. Many critical sectors in Denmark are digitized and essential for ensuring the functioning of society. This explains why cyberattacks are particularly threatening to Denmark.

In the National AI Strategy, the Danish Government states that it is a priority that Denmark preserves and develops national cyber expertise capable of protecting Danish society and the Danish defence industry against external attacks. This is done by using intelligent cyber security solutions such as the QRadar program developed by IBM. Using AI, QRadar can examine billions of pieces of information in a short period of time and look for signs that a network or system has been compromised by malicious players. The program can therefore help IT specialists find breaches of security that would be hard for a human to detect.[52]

6.2 AI Export Policies

The Danish government, through its relevant authorities such as the Danish Business Authority and the Danish Ministry of Foreign Affairs, enforces regulations and oversees the export control of AI technologies. Companies involved in the export of AI technologies from Denmark are required to comply with a set of regulations, which may involve obtaining licenses or authorizations depending on the specific circumstances.

The specific criteria for export control of AI technologies include factors such as the intended end-use, the destination country, the capabilities of the AI technology, and the potential risks associated with its use. Technologies that have potential military applications or are deemed sensitive in nature are subject to stricter controls, including technology transfer and transfer of expertise.[53]

These criteria can vary depending on the type of AI technology. For example, certain AI technologies with military or surveillance applications may face more stringent export restrictions compared to general-purpose AI software or algorithms. This was the case when Systematic in 2021 was criticized for circumventing Danish restrictions on the export of defence technology to the United Arab Emirates (UAE) via its British subsidiary company. The company was investigated for illegal software export, but investigation was later dropped.

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52 National Strategy for Artificial Intelligence, p. 21.
53 For more information about screening of autonomous weapons systems in Denmark, see Yde, Autonome våbensystemer i danske våbenscreeninger.

6.3 Need for AI Skills and Data Literacy

As stated in the beginning of this report, one of the major challenges for Danish defence in building a digitalized, AI-ready and datacentric organization is not so much technical solutions, but rather human resources. The growing knowledge gap and lack of AI literacy thus remain some of the greatest barriers for adopting defence AI in Denmark. This makes conscription and recruitment of IT-specialists, technical translators, and experts in data science a still more demanding task.

This also means that AI readiness and digitalization should be regarded as a management discipline that enables the organization to continuously deal with the opportunities and challenges related to big data and AI, including how AI is fielded and operated on the frontline.

While the forthcoming strategic initiatives may provide a framework for how the digital transformation of the organization is to be implemented, it is not at all clear where the future Danish soldiers with the right digital skills and competences should come from.

This has to do with a general lack of personnel in the Danish Armed Forces where the tasks are changing radically: Prevention and execution of various types of hybrid operations and cyber-attacks; interaction with and operating advanced unmanned systems; application of AI and quantum technology in the military toolbox. These are just a few examples of the technological reality that the Armed Forces will have to operate in within a few years.

To mitigate this huge challenge, it is crucial that the Danish defence increasingly invests in education and training. One way could be to increase the intake of so-called "cyber conscripts" by expanding the opportunity to serve militarily in the Danish armed forces in relation to cyber operations and cyber security with special focus on AI. This could also be relevant for the so-called "Hacker Academy" run by the Danish Defence Intelligence Service where the existing nurturing of talents could be expanded by a specialized defence AI talent pool.

Moreover, there could also be value generated by combining these digital recruitment and talent pools with existing alumni associations such as the Association for Danish Cyber Alumni to keep it and AI-skilled talent in the loop.[54]

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54 For more information, see: https://fdca.dk/ (last accessed 23 October 2023).

And finally, another way to "fill the gap" would be to prioritize and increase the teaching and training in AI and technology management in both current and future military education such as at the military academies and in the Master's in Military Studies program offered by the Royal Danish Defence College.

7 Training for Defence AI

As highlighted in the above section, training for AI in the Danish defence involves developing the necessary skills, knowledge, and processes to effectively understand, develop, and utilize AI technologies within military operations. This should be done by investing much more in training and education of the people in the organization.

For the moment, however, Danish Defence is not exploring all the possibilities that AI can offer for military education and training. As an example, the Command Course at the Royal Danish Defence College uses simulated exercises as an element in the training of the Danish Army's future staff officers at the battalion and brigade level. Using different types of simulation tools during the command exercises, the students get acquainted with the different roles and routines of staff work while both planning and decision-making are practiced.

In the digital part of the exercise, all input is generated through the more than 20 year old simulation program Steel Beasts. The digital simulation in Steel Beasts is created based on the students' own staff work and results in a plan that is supplemented during the simulation. Through this combination of analog and digital input, the students are exposed to a simulation that is unknown to them, and where the possibility of unforeseen actions on the part of the opponent is greatest.

Yet, the element of surprise and unexpected Red Team manoeuvres are relatively limited due to the outdated AI software in Steel Beasts. But if combined with a more up-to-date AI computer simulation that cannot be controlled in the same way as the input during the existing computer game, then the mutual actions and decisions made by the students could have a much greater influence on the situation at all levels.

The Steel Beasts example serves as a symptom of how technologically immature the Danish military education system is in incorporating cutting-edge AI technology into existing courses, training, and exercises. However, some early-stage initiatives are starting to sprout at the Royal Danish Defence College; for instance, there are ideas of creating an AI lab for experimenting and introducing military officers to the possibilities enabled by AI and Machine Learning. Such initiatives should serve as prototypes for teaching programs in AI technology at all levels of the military education system.

First, Danish defence personnel should receive specialized training and education in AI concepts, principles, and applications. This includes understanding the fundamentals of machine learning, data analysis, algorithm development, and AI ethics. Training programs may involve courses, workshops, and certifications to

equip military personnel with the knowledge and skills required to work with AI technologies.

Secondly, Danish defence should establish stronger partnerships with academia and industry, including dedicated AI centres or labs where experts and users can conduct research, experimentation, and development of AI technologies. These centres could serve as hubs for innovation, fostering collaboration, and providing resources for training personnel in AI. And they should facilitate hands-on learning, prototyping, and testing of AI algorithms and user-friendly systems specific to defence applications.

This should also involve simulation and training exercises, which are crucial for familiarizing defence personnel with AI-enabled systems and their operational implications. These exercises should create realistic scenarios where personnel can practice using AI tools, analyse AI-generated data, and make decisions based on AI recommendations. Training exercises also help identify any limitations, challenges, or vulnerabilities associated with AI implementation in defence contexts. But most importantly, training is necessary to build trust in AI systems and algorithms and make military personnel feel comfortable with the transition from a human-centric organization into human-machine teaming and "centaur"-warfighting.[55]

Finally, the future training for defence AI in Denmark should emphasize ethical and legal considerations surrounding AI usage. This includes understanding the potential biases (including gender and race), risks, and consequences associated with AI algorithms, ensuring compliance with national and international laws, and adhering to ethical principles for responsible AI development and deployment. Training programs should address the ethical use of AI in military operations, data privacy, and the protection of civilian rights.

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55 Warren/Hillas: "Friend or Frenemy."

8 Conclusion

Denmark is still at an early stage of adopting defence AI. Despite the government's vision for Denmark to be an AI frontrunner, the National Strategy for Artificial Intelligence does not provide specific guidance for the military's implementation and use of AI, focusing more on public-sector services and growth in the business community.

In spite of this, AI is being tested and used in the Danish defence for some purposes, including "low-hanging fruits" such as administrative tasks and logistics as well as in training and education. The problem is, however, that the exploration and initial testing of AI systems is highly fragmented and isolated within silos in the organization. This results in the doubling of effort and problems with sustaining the systems, challenging a near-future integration of AI into C4ISR systems that can enhance decision making and situational awareness.

Danish defence collaborates with the defence industry and academia regarding new partnerships and research of defence AI. Unmanned and autonomous systems with AI capabilities are furthermore being tested and evaluated for tasks such as intelligence, reconnaissance, and surveillance operations where AI is used for automation purposes such as creating waypoints and calculating routes.

However, there is a growing knowledge gap and lack of AI literacy in the Danish defence organization, which makes the recruitment of IT specialists and data science experts an increasingly demanding task. Although the Danish Chief of Defence has emphasized the importance of investing in AI and data processing software, the real challenge will be to recruit or educate the right people with the right skills and competences to make proper use of these AI-enabled data and software systems. And in this endeavour, it remains pertinent to create a culture of thinking about technology, including defence AI and data, not as barriers but as something that the organization can profit from.

The need for efficient data management and software systems has become evident with the procurement of advanced military capabilities. Danish Defence recognizes the criticality of data and digital networks for operational success, and future operations are integrated across multiple domains. Yet, the increasing amounts of data gathered from advanced sensor platforms is not always used properly because it rarely reaches further than the crew in a fighter plane or frigate. Therefore, Danish Defence needs to adopt AI as a part of the development of a much stronger digital backbone to process the increasing amount of information and share it across platforms, units and domains. Especially the latter is important if Denmark is to remain relevant for its allies in NATO and abroad.

While Denmark acknowledges the importance of defence AI and digitalization, there are huge challenges to overcome. Above all, the growing knowledge gap

and lack of digital literacy is considered a major risk and should be met with investments in education and training.

In other words, the Danish Defence aims to leverage AI to improve operational capabilities and decision-making processes, but careful consideration is required to ensure responsible and explainable use of AI in alignment with international norms and standards.

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