HCSS Security

The Implementation of Robotic and Autonomous Systems: The Future is Now, prepare for 2045

Patrick Bolder, Michel Rademaker & Bianca Torossian

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1 Introduction

Over the last two years, HCSS has conducted research on Robotic and Autonomous Systems (RAS) in a military context concerning several aspects and dilemmas. Throughout this paper on the implementation of RAS, we hope to inspire thinking and stimulate the reader to reflect on the future use of RAS, draw recommendations towards the year 2035 that fit within the 'Operationeel Kader voor het Landoptreden' (and align these recommendations with the foreseen 'Defensievisie 2035') and consider recommendations for the implementation of RAS towards the year 2045.

The rationale behind looking far into the future is twofold. First, significant questions must be addressed early in the development and implementation of RAS. Many technologies are still in their infancy and similarly, our understanding of the political, strategic, tactical and, operational application of RAS is in its early stages. The second reason stems from the idea that people tend to overestimate the maturation of technologies in the short term and underestimate the speed of technological developments in the long term. Thus, by using both shorter- and long-term time horizons, room is created to think out-of-the-box whilst simultaneously lending opportunity to plan against a plausible, but—not yet ready—future.

This paper assesses some relevant elements for the implementation of RAS into the armed forces and especially the Army. It raises questions regarding the formulation of concepts and doctrines, how command & control over RAS is organized, and the consequences of these changes for personnel (including their training), logistics, infrastructure, organizational processes, and leadership. Throughout this paper, questions raised will not always be explicitly answered. This is because, in many cases, it is still too early to provide clear solutions. However, further disentanglement of the issues mentioned will help discussions and, eventually, decision-making. In many cases, answers can only be realized after first experiments are conducted and experiences working with RAS are gained. Therefore, it is improbable that the thinking reflected in this paper is complete. The paper rather provides first thoughts and some conceptual points of view on issues the military will face in applying RAS within their organization and work. For insight into the challenges outlined in this paper, HCSS conducted an expert session using a serious game, the results of which are fully integrated into this paper.

Against this background, this paper develops recommendations regarding which lines of development or policies must be developed, the timeframe by which this should occur, and the prerequisites for these policies.

2 Methodology

Based on research HCSS conducted throughout the two-year project, Robotic and Autonomous Systems in a Military Context, elaborations took place regarding several dilemmas and issues pertinent to the implementation of RAS. During the project, papers have been developed on the operational applications, ethical dilemmas, legal aspects, collaboration and concept development and experimentation (CD&E).

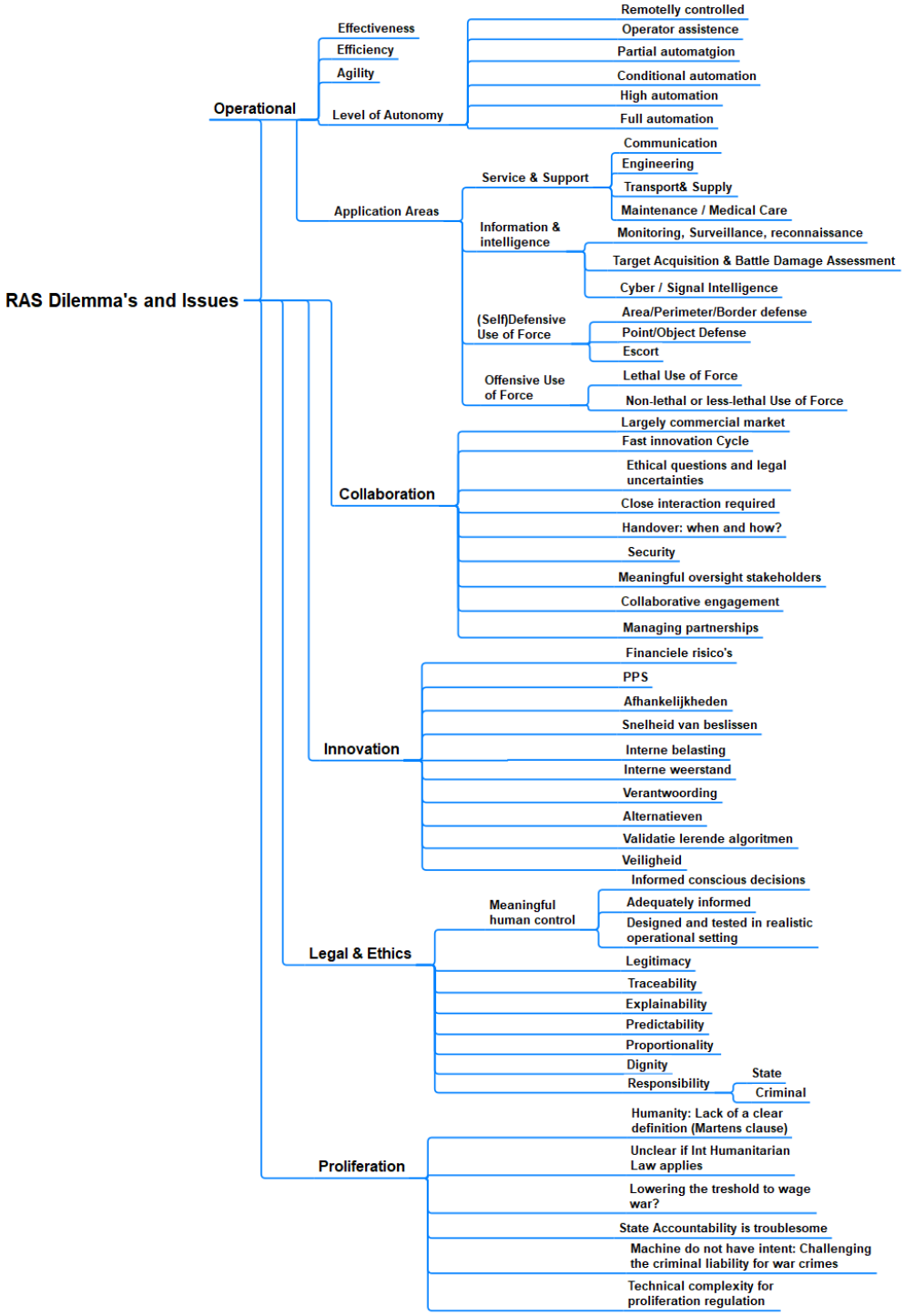

Figure 1 RAS Dilemma's and Issues relevant during implementation.

As the first step in this paper, a future perspective is constructed through an anticipated plausible scenario and a short statement or point of departure for the analyses. This scenario is situated in the year 2045. The breakdown of the scenario into snippets of personal stories was chosen to make it as concrete as possible, and to ensure it was relatable and understandable for different audiences. Integrated within all snippets are the dilemmas or issues that were identified throughout the two-year research period. In the scenarios section (and subsequently throughout this paper) new terms, such as 'wolfpack', 'fleet' and 'line', are introduced to describe military levels of command. This enables us to detach from traditional thinking on levels of command.

A second step of the analysis conducted was the construction of a future RAS unit. Insights gained from the research paper on the military applicability of RAS were taken into account and then extrapolated into a plausible set of future systems. To build the future RAS unit, these systems were combined to form a unit that is only slightly akin to a current-day combat brigade.

A third step delineates four lines of development that explain in some detail what is required to undertake the implementation of RAS into the armed forces. At this point, HCSS conducted an expert session using serious gaming tools to gather further insights and validate our thinking.

3 Scenario: "2045: the era of relentless competition"

The Great Power Competition which started in the late 2010s has exacerbated over the last 25 years, never leading to wars on a worldwide scale, but instead resulting in high tensions globally.

3.1 Point of Departure

Due to geopolitical developments and continuous support from the Netherlands to the EU mission portfolio, a reorganization and restructuring of defense organizations has taken place. Deployment of units is no longer an aberration of peacetime training and education, but rather the new norm for Army units that operate on the ground. *Operation Permanence* has become the new normal whereby rotations from barracks to deployment areas are continuously taking place, but the footprint in theatre is as small as required, made possible by intelligent communications systems and innovative maintenance procedures. Reachback is structured in a new way so that those working in the Reachback offices are part of the actual operation without physical presence in theatre.

Work at the Reachback HQ involves creating the digital twin of the actual battlefield/area of operation. Data fusion from all available sensors in traditional military domains, as well as from the Electromagnetic spectrum, Cyber domain, and Cognitive dimension is delivered and presented by the Data Science Cell. Through an enormous amount of slightly different scenarios based on this data and its applications to the current operation, so-called Ensemble Comparison points out the most likely scenarios and their implications. These are then further analyzed to prepare the deployed units for their tasks. Through these means, it is possible to continuously observe the overall situation, learn from the theater digital situation overview and drill down on the specific critical localized elements for operational and tactical execution of tasks. Through targeted deeper intelligence gathering, (mostly automatically

generated requests for information (RFI's) by AI systems) we can now discern the needles within the haystack and can act upon neutralizing or utilizing those needles.

Other work at the Reachback HQ concerns the development and training of algorithms to feed into the deployed RAS. The continuously changing requirements for new algorithms are written here and the development of existing algorithms can occur in a Company-Owned Military-Operated (COMO) construct.

3.2 A short history of main events

3.2.1 Climate change

Climate change has had a more severe impact on world stability than the Covid-19 pandemic of 2020/2021. Competition between states and blocs established themselves more prominently under the pressure of a changing climate, leading to pressure concerning the security of supply of rare earth elements, agricultural areas, food, and water.

3.2.2 Geopolitical developments

Climate change and increasing national and regional self-assurance have led to a state of continuous competition, keeping world leaders on their toes. Cooperation is defined as 'friendly but cautious' between the powerbrokers, whilst at the frayed edges of the world, unsettling situations and events take place which need to be confined and managed to prevent spill-over to the more developed world. Even though there are regular meetings of the leaders of the BIG8 (North America, South America, EU, Russia, China, Australia, African Union, and the Group of Non-Aligned Nations), trust is not common amongst them. Outlier states (e.g., North Korea, Iran, Venezuela, India, and Pakistan) derive their position from unpredictable and erratic behavior, often supported by their possession of nuclear equipment and arms.

3.2.3 Consequences for the EU

It has taken time for the European nations to come to the same conclusion, but all saw their future best served by strengthening the EU and put to rest the continued disagreements about budget rules and national deficits. European regional autonomy is widely accepted by EU leaders as the only sensible way forward. In 2025, an ambitious EU policy was implemented, spanning more areas for communitarian cooperation than ever.

Security and safety nowadays are newly defined concepts and have a wider reach than they had in the early years of the 21st century. Former 'basic human rights' have become so pressured in other power blocs that they have been adopted in the EU as culture: morals and ethics worth fighting for. The newly defined notions of security and safety are not only about territory and free trade but also concern subjects as food security, human rights, development goals and freedom of gender, speech, religion, thought and expression.

As the EU's economic strength is also served by global trade, border security had to be redefined as well. This was not achieved by completely closing borders but rather by controlling them to allow for seamless but safe flows in all domains as critical and innovative solutions were developed. These solutions were deployed not only in the physical domain but also in the cyber domain, which was much in need of advanced

protection, rules, and laws. Since the space domain has become more accessible, critical materials are now also mined on nearby asteroids, which led to new kinds of borders with new kinds of security issues in new domains.

3.3 Main missions for the EU

The EU's posture is one of constant alert, leading to the continuous deployment of troops and their equipment along the sea-, air-, and land borders of the Union. The cyber domain is an a-typical phenomenon as borders are not easy to discern, but security here has become almost more adamant than in the physical domains. Also, security in, to, and from the space domain is now one of the missions the EU Security Council decided upon in 2042 when the new EU Security and Safety Strategy (EUSSS42) was adopted. Within the European security environment, burden sharing, and mutual responsibility became the new norm for the enhanced and intelligent border protection missions. For almost all European nations this means that military units are on a rotational schedule for the basic set of the so-called 'Primary EUGuard Missions' (PEM) as described in the EUSSS42. These vary from '*space surveillance and evasive maneuvers*' to '*maritime patrol and engage*', '*air defense and deter*', '*land observe and deny*' and '*cyber protect and defeat*' missions. The required stamina for these missions could not be guaranteed by human force alone; developments in AI and Robotic and Autonomous Systems (RAS) were not only welcome but instrumental in safeguarding the European continent.

3.4 Important role for the Netherlands

The Royal Netherlands Army had already started to experiment with the deployment of robotic systems in the late 2010's. High numbers of RAS make up for the lack of sufficient personnel. This enables the Royal Netherlands Army to execute prolonged forward deployment for the *'land observe and deny'* PEM-missions along Europe's stretched borders. As the Netherlands (with The Hague as the City of Peace and Justice) is known for its application of law in all facets, it is seen as the guiding country concerning autonomous unmanned systems and its implications for all aspects of legal and ethical issues such as (amongst others) 'meaningful human control' and legitimacy in the use of violence.

For that reason, the Royal Netherlands Army is currently heavily engaged in the '*land observe and deny*' EU-mission called OSIRIS (Operation Southern International Reaction-Intervention-Security) in the northern Nile delta in Egypt. Their mandate comprises border security and prevention from human trafficking, weapons smuggling, and data crimes.

The challenges for the Royal Netherlands Army unit on this mission are considerable. The opponent, the Free Organization of Egyptian Identity (FOEI), supported by troops from neighboring countries, such as Sudanese fighters, has acquired advanced technologies in unmanned systems and Artificial Intelligence. There are strong indications that the Russian-affiliated Beethoven group is heavily backing FOEI forces. Though Moscow denies involvement, international passenger records show that several young Russian men and women are having holidays in the region. FOEI leaders have said that they rely on the force and fearlessness of autonomous weapons systems,

even if some aspects of them are still in an experimental phase and not made subject to International Humanitarian Law.

3.5 What does the future look like from the perspective of a user?

In these snippets of the future, both our own troops and adversaries come into play. We have sketched their roles and have included dilemmas and issues, addressing them in a plausible future where RAS applications might have a prominent role to fulfil.

EU-OSIRIS:

Camilla Draper, CEO of Draper Robotics had a short night. After having been up for some 24 hours, she was again awake very early in the morning. Last night, her company was requested to update some of the applications of the unmanned systems running in the Northern parts of the Nile river borders. Dutch land forces are participating, as part of the EU-mission in this hostile territory and some of her employees have a part-time reservist role embedded in the unit there too. Her contracts provide what is called Company Owned Military Operated (COMO) services. She provides on short lease drones and autonomous ground-based robots and even two types of amphibious and underwater surveillance drones. The military uses these robotic systems, and her team assists in the upkeep and technical operational services both back home and in theatre. For some, logistic functions Draper Robotics provides full services, meaning that they do the maintenance, keep stock, have SLA's for providing replacements of modules or complete systems within max six hours from in-theatre, dispersed forward storage and maintenance sites, etc. These sites are integrated into the logistics information systems the military units use. For use of force the military are the operators. But it is the combination that made her company stand out. For her, it is profitable and for the military, the benefit is flexible and diverse capabilities, cost-effectiveness and the ability to focus on core-tasks. She managed to update the unmanned systems within 30 hours, implementing the software her team developed over the last two weeks. Even after this short night, she could not sleep anymore as she realized that she was on a slippery path now regarding the handover of her new software to the military, as the division of liability between the operators and her company became questionable by this update.

FOEI troops and its affiliates:

Boris Krygizie, director of BEAR Robotics, had an exhausting week. For seven days in a row, he has met the chief innovation of the FOEI military RAS unit and the Army staff section that oversees all commercial parties during the life cycle of the unmanned systems. They discussed at length the latest system feature that would allow one of the systems to threaten and/or harm a human being while interrogating. According to Boris, this innovation could help the forces to win the conflict in the Northern parts of the Nile river borders against the EU-mission. However, according to the Army staff this might be a tactical win but could endanger the legality of their mission in the eyes of domestic and international society. In the end, all his hard work went down the drain as it was decided that the latest feature would not be installed. However, all is not lost: Boris might sell the feature to a friend who is the director of a private military company that operates in Mexico.

EU-OSIRIS:

LtCol Jack Jansen has become used to COMO-services over the last ten years and has seen them mature during his time commanding three WOLFPACKS[1] in the Nile Delta theatre. They have a soldier-to-robot ratio of 1:6. He has 75 troops of which 50 are partaking in 24/7 operational combat and combat support tasks and up to 300 robotic and autonomous systems (RAS) to help them in both defensive and offensive roles. This is the equivalent to the capabilities of a battalion back in 2020. Most of the RAS are integrated, meaning that they are partly coordinated autonomously and work in swarms up to 20 (a number tested as being effective for a single operator to handle at this stage of development). Every combat soldier can control a swarm and extend their capability tenfold. During several missions, it appeared that his unit had a high deterrence posture. A WOLFPACK is nowadays capable of operating at two levels at the same time. Jack walks alongside conditional automated systems that defend the perimeter. Though the systems are switched from 'conditional automated' to 'operator assisted' meaning the systems will not fire on him autonomously, Jack, despite so many years of experience with RAS, is still not very comfortable walking in front of the autonomous systems.

As RAS provide full situational understanding and can integrate vast information across the operational theatre and at home, unused capacity is automatically identified, and the surplus is available to his unit (and vice versa). With drones and unmanned systems, the mobility of his unit has improved dramatically, and the footprint has reduced. In addition, his effective warfighting reach for the smaller systems has extended from an average of 3 kilometers around his unit elements to some 30 kilometers, meaning that his coverage of theatre is six times larger than it used to be. For him, as a commander, it gives a much better awareness and understanding of his options. The situational picture has greater depth and updates are constantly available, which means that his briefs and operational orders have a different nature. The situation at hand is sketched automatically and several plausible scenarios are generated including plausible courses of action. Because of the availability of vast data from all sensors in his unit and others, data analytics supported with AI provide a better risk assessment than he was used to some ten years ago. Simulation runs, or so-called "dress rehearsals" are the standard practice these days. But all-in-all his skills mastering the art of war are still required.

FOEI troops and its affiliates:

Former LtCol Youri Nikolajev has been heavily involved in RAS units over the last ten years. He operates in the Nile delta as an advisor to the FOEI militia that controls several unmanned systems. Some of these systems can be adapted to the situation and the task within 24 hours: one day the system defends in high automated modus an object, and the next day the system conducts an attack on the EU soldiers in remotely controlled modus. Youri analyzes the options his Command & Control device has produced for the upcoming operation next week; now he must decide whether to use his less sophisticated drones for communication, for supply, or medical care. These legacy drones require 5 days of

[1] Throughout this section, and subsequently throughout this paper, new terms, such as 'wolfpack', 'fleet' and 'line', are introduced describe military levels of command. This enables us to detach from traditional military organizational thinking and broaden our creativity, and furthermore represents how our conceptual framing of units will shift in the coming decades.

rebuilding and software-updating. Luckily, he has received plenty of modern information and intelligence systems in the last month. These systems provide him with a clear picture of the EU forces. Besides that, these systems propose which targets to engage. Youri is convinced that at the end of next week his Egyptian militia will have won a major battle. It could have been better if the militia had not wasted the five mini-mine laying systems two weeks ago.

EU-OSIRIS: Major Estella Hansen has recently changed her position from project-leader in the Defence Material Organization to commander of an operational RAS unit. She trains her operators to understand how their systems 'think'. According to her, the operators must understand how their systems decide to engage targets because in the end the people behind the systems are accountable for the behavior of RAS. If the operators are not able to predict the system's behavior to a certain degree, they are not able to override the system if it malfunctions. She knows that her systems do not decide well on proportionality. Therefore, the operators must override the systems during offensive operations using lethal force against the Nile delta militias to avoid civilian casualties and stay within International Humanitarian Law.

FOEI troops and its affiliates:
Major Umit Sjukoev has recently changed position, from the commander of an operational RAS unit to project-leader in the Airforce staff's RAS section. Now he is in the position to oversee the whole life cycle of his beloved unmanned systems. At this moment, Umit writes the requirements for a new drone. The drone must decide itself which target it will attack. Chapter 3 of the requirements describes how the Airforce keeps an overview concerning the drone's adherence to the ethical regulations set by his country from the designing phase through to the manufacturing, testing and operational phases, and finally the decommissioning phase. The telephone rings and Umit must explain once again that the systems, contrary to human beings, do not get tired and emotions do not influence decisions.

EU-OSIRIS:
Captain Jan Jager directs the Lethal Autonomous Weapon Systems towards the Sudanese militia that marches in large columns to their defensive positions close to the Nile. Despite his relative weakness (due to the small number of systems) he was not afraid to attack this massive militia nor does he care about losing his systems, as he will receive another batch next week.

One of Jan's concerns is to adhere to the principles of International Humanitarian Law. For him this is very difficult because RAS are not mentioned in International Humanitarian Law, but Jan intends to follow the principles embedded in the tailor-made rules of engagement. The time he has used to come to the decision to attack has lasted much longer than the attack itself will take. He believes that an outsider could think that such a decision to wage war by RAS against humans would be easy but for him it was not.

Within a few minutes he is about to let his systems go. As of that moment, the systems are on their own, taking decisions to destroy, based on previously set rule-based engagements. Jan knows that some mistakes the systems will make will not be traced back to him or the system's manufacturer. He has no idea which entity

would be accountable in such a case. He pushes the button to let his systems attack the militia.

FOEI troops and its affiliates:
Militia leader Abdo Majok directs his massive militia in marching columns to their defensive positions close to the Nile. Abdo expects an attack by the EU unmanned systems units on his left flank. He doesn't mind losing half of his militia as within three weeks he will receive new soldiers. He has tasked his left flank security patrol to capture some of the enemy system, he aims to sell these captured systems to terrorists in Nigeria. For Abdo it was easy waging war to gain money. He just must be careful that his government was not accountable for the activities of the mercenaries in his government-owned militia.

EU-OSIRIS:
Colonel Mats Verbraak has been preparing the implementation of the COMO-contracts for RAS since 2025. The land forces underwent a steep learning curve, as did the companies that provided the COMO-RAS-services. The 'teeth-to-tail' ratio has been tremendously improved. Training and exercising are more efficient and effective, and the speed of innovation has more than tripled. Much of the training is provided using fully automated simulations not only in the preparation phase but also in theatre. All these capabilities are provided in close collaboration with knowledge-intensive partners and COMO-companies. Due to the uncertainty regarding the amount of effort it would take to develop and test an innovation, the Army staff is flexible with his budgets. Mats appreciates this and continuously informs the Army staff on the financial aspects of his COMO-RAS-services. His strategy is to get at least two manufacturers involved in one system to facilitate competition between these manufacturers, otherwise he would run out of his flexible budgets. Mats' headache worsens as he must decide whether to incorporate the sensor-module in the next phase of the drone or in a later phase. Neither the sensor-module nor the drone is mature enough now, but both might be in time. Uncertainty and risks further complicate Matt's dilemma, but he must decide quickly. If he incorporates it in the next phase, he must use the scarce testing capacity from his other RAS project.

FOEI troops and its affiliates:
Colonel Bukin Sarachov has been involved in the implementation of RAS since 2025. Normally, he likes the speed of innovation with all the related challenges. But now, he prepares for the hearing with the General Court of Audit: he must explain the failed implementation of an autonomous transporter for wounded personnel.

His decision to speed up the testing phase required regular units to change their schedule of exercises. To achieve this, he fought internal bureaucracy to start the testing phase within 4 months. All the tests failed; the whole project turned out to be a disaster. The human-centric units blamed him for wasting so much money on useless innovations. Bukin will explain to the Court that he had pushed the testing phase too early, but there were alternatives less autonomous than the systems that failed, that could have been procured quickly. However, due to the widely spread criticism, it was politically impossible procure an alternative system. Bukin will elaborate in court a previous experience without a proper testing phase when he fielded an ammunition supply system in the Nile delta two years ago. The system's

algorithms learned a lot and the system developed into a more autonomous system after a year. In that case he received the critique that the algorithms were not validated enough because learned behavior had been gained in an operational environment instead of in a controlled testing environment. Indeed, in a few cases these autonomous supply systems failed to deliver the ammunition safely, however, not everyone is willing to bear responsibility for this issue. Walking into the court's largest room, Bukin noted that some colleagues were not as open-minded to RAS.

4 The Unit of the Future

Considering these fictious—but foreseeable—scenarios, considerable changes to the structure, command and control procedures, and organization of the army are necessary. This includes all kinds of Tactics, Techniques and Procedures (TTP's) and perhaps doctrines. HCSS is not in the position to prescribe **how** these changes should take place and **to which end-state**, but we can assist in drawing focus to the **areas to change** and the **direction** of that change.

In order to give a hands-on idea of what a future unit could look like when RAS would be fully applied, a plausible unit was constructed. The insights gained from the research paper on the operational applications of RAS were considered and extrapolated into a plausible future unit that is only slightly recognizable comparing it with the current-day 13Th Brigade.

In 2045, the organization of the 13th Brigade is focused on RAS developments. The organization does not encompass all developments in other expert-lines (such as logistics or cyber-operations for example) up to 2045. The scenario outlines how the brigade is deployed in the Nile delta, with some elements more detailed than others. The non-deployed ('peacetime' organization in the Netherlands) organization might be different from the deployed one.

1) Brigade HQ
   a) Staff are static in the Netherlands, the Reachback HQ
   b) Staff forward deployed

2) Logistics
   a) Medical company
   b) Software repair, development & test company (including Reachback group to Army RAS organic capability and to the companies that provide the 'Company Owned Military Operated' services)
   c) Hardware repair, development & test company
      (partly manned by Camilla Drapers civilian technicians)
   d) Supply company (a multi-UGS and UAS in a network)
   e) Robot recovery company

3) 5 LINES of sensors (each LINE consists of an Analysis Cell with several sensors, UGS and UAS)
   a) The analysis cell is split in a forward deployed element and an element in reach back in NLD.
   b) The non-disposable UGS is the Cyclops RAS which conduct surveillance, target acquisition and reconnaissance. With its on-board AI-fueled systems it churns out intelligence products. Where essential, to prevent human decision-making

latency, self-defense systems are employed by the Cyclops.
Smaller systems that can operate in urban areas, in wooded areas, etc. belong to the inventory. Further on, each LINE of sensors possesses a huge amount of small disposable UASs that are able to operate together with loitering munitions of the FLEET.

4) 1 FLEET of shooters that covers all areas of the Brigade.
It employs small to large munitions in massive amounts, partly loitering munition (short and long endurance), partly the munitions are able to attack in swarms. The hardware consists amongst others of Israeli developed, Dutch (REKKOF Military Industry) produced Stingray Multi Area Target Suppression (Stingray SMATS) Systems.
The loitering munitions are able to operate in swarms with the LINES' small disposable UASs. These swarms can mount up to 5500 UASs and loitering munitions.

5) 6 WOLFPACKS of sensor-shooter-combinations
   a) Command cell
   b) Support cell (including software development group, civil engineers of COMO services, Forward cyber operators, Forward non-lethal influencing operators, Electronic Warfare group, logistics) supply/maintenance/medical)
   c) Several sensor-shooter-combinations (UAS and UGS)
      equipped with:
      i) The standard Wide Range Observe, Precision Application Fire (WIROPAF) Unmanned Ground Systems for automatic close-in 450 degrees (360+90) able to destroy or suppress a target in lethal and non-lethal ways.
      ii) The short range UAS 'Observe and Fight Bird' can be equipped (for each action) with a certain ammunition, combined with a couple of sensors.

6) 30 Defensive SECTIONS; defense against ground, air, and electro-magnetic attacks, meant to allocate to other Brigade actors for self-defense of that actor.
   a) Command cell
   b) 22 soldiers with 50 ground defense systems
   c) 18 soldiers with 40 air defense systems
   d) 13 soldiers with 10 electro-magnetic defense systems

   Consisting of the family of Hornet's Nest unmanned systems, due to its easily understandable and accessible AI applicable in multiple domains and easy reprogrammable and adjustable for various tasks.

7) 1 battalion of motorized infantry (3 companies of motorized infantry with each 3 platoons)
   The platoons use Milrem Robotics latest UGS for a wide area of support and relief tasks enhancing the soldiers' effectiveness in battle.

8) Suasion battalion
Electronic Warfare, cyber operations, non-lethal-behavior-influencing-capability

9) 4 Environmental reconstruction BLOCKS (Mine laying systems, Demolition systems, Mine clearing systems, Bridge laying systems, Breach systems)
Equipped with highly technical advanced UGSs where, based on AI and recognition algorithms, largely autonomous activities can be delegated to. The systems can be remotely operated via a datalink and ground control station by an engineer operator. The mine laying and demolition systems can also be tasked by the obstacle plan enhanced by the current 3D photomap for autonomous task execution.

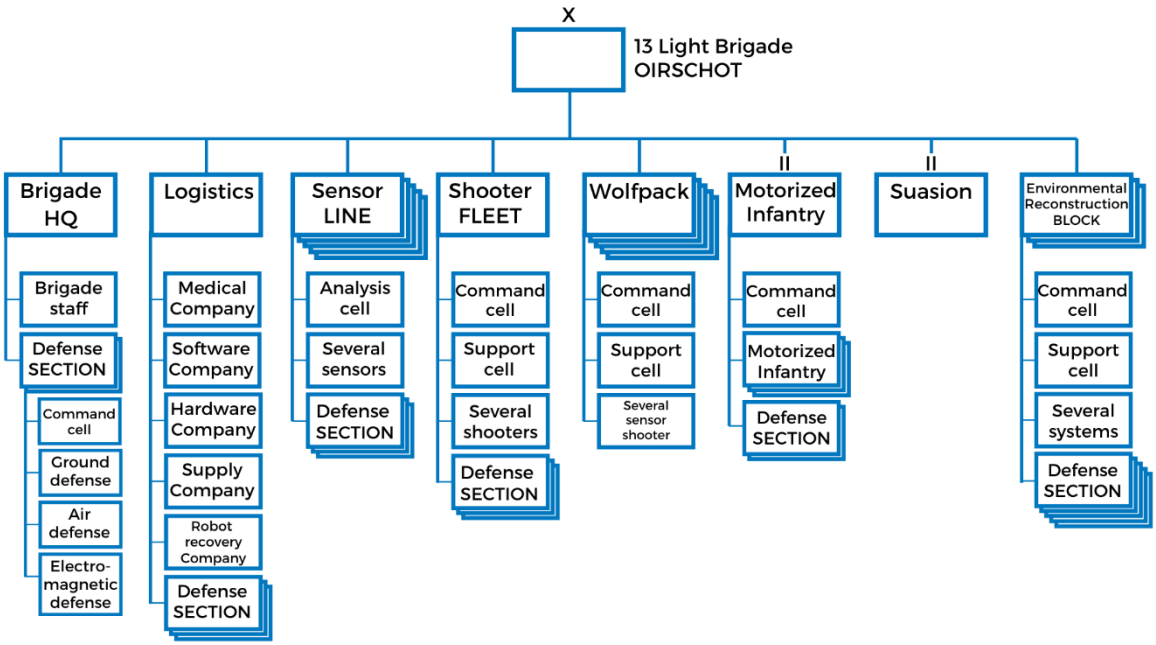

Figure 1 A 2045 Army Combat unit

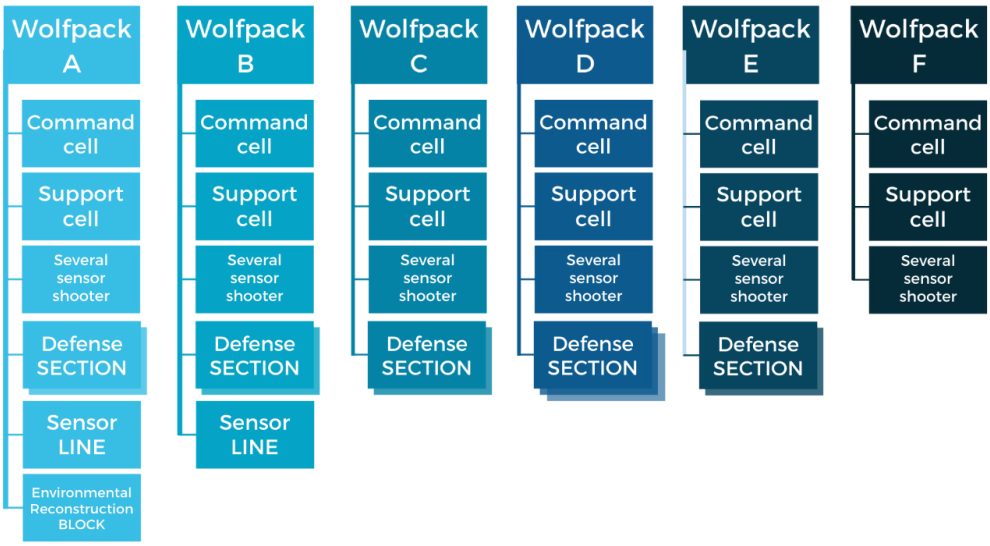

Figure 2 The 2045 Wolfpacks

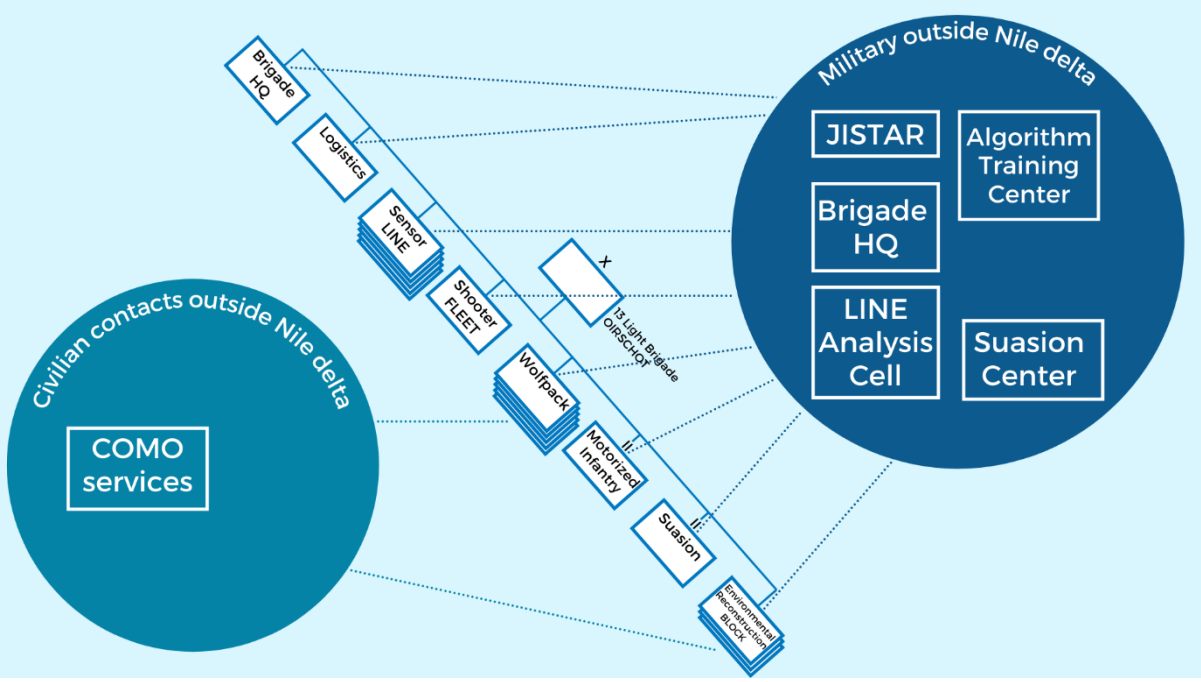

Figure 3 The 2045 Reach Back construct

5 Back to 2020: Lines of Development

For the implementation of future RAS capabilities, various initiatives must be undertaken. Based on the plausible future scenarios explored in the previous section, which represented many of the dilemmas and issues at hand, a series of lines of development can be identified. For each line of development, a description is outlined, and relevant aspects are addressed and operationalized by linking items with policy developments and other activities already underway. This includes strategy and plan development, policy and operations concept development, innovation, adaptation issues, finance, recruitment and human resource issues, norms, legal queries and public support.

The description for each Line of Development lists philosophical and open-ended questions which are designed to provoke in-depth discussions. These can relate to new doctrines, concepts, working cooperation, business models, etc. It is foreseen that developments will continue to take place and constant adaptation of the organization is required. The biggest lesson to be learned here is that to tackling all developments in a coherent way requires leadership and trust.

5.1 Line 1: Development and acquisition

Technological developments are underway but still require a significant testing.

We are at the stage when (r)evolutionary technical developments no longer stem solely from military research and developments. Long gone is the period when advanced military technology was introduced for soldiering purposes, eventually finding its way to civil society for day-to-day peaceful and domestic use. Commercial companies, producers and factories nowadays see innovation as a means of survival, and it is thus embraced with much enthusiasm. This attitude towards thinking about constant

renewal of business processes and products takes place throughout the commercial world. The civil techniques and novelties found there can fulfill military tasks after some adaptation if necessary. However, for purely military tasks (e.g. (supporting) warfighting, civil-developed innovative techniques) RAS will probably need considerable adjustment to be effective. From this perspective, it is fair to say that in the field of military RAS, civil-developed techniques will have to be reinforced with military knowledge and specific development. At this point, RAS and especially military RAS, are still in its embryonic stages, meaning not much is tested and ready for action, let alone ready for immediate use.

Here arises an important decision point: Should the Netherlands armed forces act as a smart buyer of existing technology, or do they place themselves at the forefront of technological advancement and be a part of the design and development? As previously stated, RAS is in its first stages of development and if the Netherlands Armed Forces do not have the luxury to wait for military off the shelf products, it will need to engage in the development of RAS. RAS will probably have to be developed according to specific demands from the MoD. For the Netherlands, this represents an excellent opportunity for triple helix cooperation whereby knowledge institutions, commercial firms and factories, and the armed forces can articulate the need and applications for (different types of) RAS, set design parameters on hard- and software, and undertake prototyping activities. Here lies the best chances to provide specific military needs. In a form of spiral development, where all parties concerned work close together and have short feedback loops, such an approach offers the best chances for quick success.

The development of RAS will probably occur in revolutionary steps as through each phase of advancement new areas and possibilities will be discovered and defined where RAS can serve and add value to human skills or even replace them. To foster such a development path, serious thinking should be allocated to realistic, yet safe test environments. The result of a spiral or (r)evolutionary project-design should consist of a technology demonstrator, leading to an operationally usable and effective prototype. This prototype will likely lead to a better understanding of capacities and lead to further ideas and idea expansion. The above-indicated approach fits within the Defense Industry Strategy recently adopted by Parliament. The Ministries of Defense and Economic Affairs are strong supporters of providing domestic industry with the best chances to participate strongly to the profitable defense and security market. Such a movement requires an attitude of entrepreneurship within the Defense organization in order to bring all involved parties on board. But due to internal sets of rules and regulations, even when this point is reached, it will also lead to challenges in the field of acquisition and procurement. A culture where innovation is fostered as a competency of the utmost importance will contribute to making the above developments a reality.

Current guidelines on defense acquisition have firm rules regarding business competition and offering a level playing field to all interested industries. However, it is sometimes difficult to involve ‘first-stage developers’ who are in the stage of offering their product into competition with other possible providers. Due to their previous involvement, they are in possession of important and strategic knowledge which could

give them an advanced position and consequently would deprive other suppliers of a fair competing chance. The result can be that the company which bares the biggest financial and technical risks is excluded from making a profit that reflects their degree of risk. By publicizing their findings to the market, a level playing field is created, but companies lose their knowledge position as a result. This is a significant deterrent for adventurous and innovative firms to participate in the development stages of new weaponry. Subsequently, it can be reasoned that such an approach halts innovation. Newer approaches on acquiring technologies are leaving behind the buying new systems. Leasing and using the capability without owning the system itself, is a business model that will become increasingly more present in the military. The distinction between 'owning' and 'using' will have to be explored, particularly when it comes to responsibility for maintenance and malfunctions.

Another issue to tackle within procurement policy is in relation to numbers and batches. The military prefer to have a high degree (if not the maximum) of commonality throughout a 'fleet' of certain weapon systems. In their eyes, this will ease the logistic and maintenance efforts because the production and servicing of the equipment can occur *en masse*. Further, in terms of interoperability, there are advantages of a common fleet. With RAS, development will never be over and improvements and enhancements, as well as new capabilities, will be added over time. Instead of looking at maintenance issues simplified by standardization, the positive side of maximum capabilities and possibilities should outweigh the perceived negative ones.

Innovation partners

The construct depicted in the partial scenarios is on COMO (Commercial Owned Military Operated), a business set-up that has no preceding examples when it comes to the use of military equipment in active firing zones. This will challenge the creativity of contract managers and will lead to the development of advanced business contracts. The innovation of processes and capabilities will have to take place within the Defense organization and new avenues of approach will be invented. As this is about equipment that will not be completely out of the development stage for the coming years, the innovation partners should not only include the hardware and software providers, but also knowledge institutions and other non-standard scientific disciplines.

5.2 Line 2: Operational Excellence

Redesign of concepts, capability packages, doctrines and TTP's will require a reshuffle of capabilities when developing and implementing RAS. Traditional capabilities might be obsolete or less effective, while others might be boosted even more.

Military operations, their planning, tactics, and conduct have their roots in concepts and doctrine. Concepts and doctrine describe what is done in operations, how they are done and which rules to act upon during operations. Concepts and doctrines prepare soldiers for the 'fog of war' during operations. Circumstances and conditions change during battle, which are sometimes or partially foreseen. Training for all exceptions and aberrations from the set-up plan is impossible but preparations towards the unknown and unexpected can and must be done by utilizing concepts and doctrines. Concepts and especially doctrine will give soldiers confidence through which they can fulfill their tasks even under harsh and dangerous circumstances. Concepts and doctrines in this

way also define training and preparedness. Though concepts and doctrine fulfill purposes and are often the backbone of planning and training for operations, they are not set in stone and should be subject to evolution over time and practice.

The introduction of new systems can lead to the performance of new tasks or a change in the way existing tasks are performed. This is especially the case when these new systems are revolutionary in nature rather than a next iteration of existing weaponry. In this case, new types of weapon systems can, and in some situations, must lead to the adaptation of concepts and doctrines. It is likely that over the years the value, the number of tasks, acceptance and usability of RAS in the military environment will expand. The first RAS will be assisting human soldiers in simpler tasks such as carrying heavy equipment, scouting ahead and setting up secure communications. Gradually, RAS will become assistants of human fighters, supplying and sending intel through their advanced audio and visual sensors, including through the infrared spectrum and radar, whilst simultaneously receiving information from other sources as well. Another task of early RAS can be maintaining radio contact with higher and lower echelons and neighboring units, ensuring that the supply lines for equipment and the transport of casualties from the battlefield is organized, all whilst being accompanied by a precise GPS-tracking system to prevent friendly fire. RAS will also be carrying heavy weapon-systems and possibly operating them alongside human soldiers. A further development will be circumstances whereby RAS replace human soldiers almost completely, especially in extremely volatile circumstances, unfit for humans. In all stages, the freedom of movement of the employed RAS will have to be defined and the level of autonomy decided.

All these different modes and levels of operation must be 'learned' by RAS, but also or even more so by the human operator or the human working alongside RAS. How this cooperation should take place, and the most effective means of man-machine teaming, will have to be developed and put into doctrine. Especially in cases where RAS will take over increasingly complex functions from humans, these doctrines are essential for optimum use of all capabilities that RAS offers and to ensure the operations are as safe and ethical as possible. Ever-tightening decision loops require increasingly quicker sequences of observation, orientation, decision and action (OODA-loop). One way to approach this accelerated decision-making is by introducing high levels of autonomy within weapon systems. For defensive weapon systems, this is probably the only way to be inside the opponents' OODA-loop.

Introducing RAS within the military might ultimately lead to broad changes within organizations, as indicated earlier in the 'Future Scenarios' section. This trend of applying increasing levels of autonomy has already taken place. Armored vehicles like tanks and APCs can be equipped with reactive armor, chaff and flare can be dispensed in automatic mode from endangered aircrafts and naval close-in self-defense systems must be on automatic mode in order to be effective at all. Air defense systems already can apply a considerable amount of autonomy as proven by the Goalkeeper, Patriot and NASAMS systems. Once on automatic setting, they can detect and identify targets and decide to launch ammunitions and missiles to neutralize those targets without human interference. Although these systems have limited tasks, they have introduced a level of

autonomy which has become acceptable. The further levels of autonomy will become not only acceptable but essential.

Another challenging doctrine development will take place when RAS are deployed in fighting missions and especially where they are at the forefront of the conflict. When humans are wounded the so-called golden hour is applied: within the hour the wounded must be treated in a hospital. If a soldier is killed, colleagues want to make sure they are not left behind on the battlefield. Do we apply the same type and level of ethics to machines? What rules and doctrine concerning damage will we have for RAS? If a system is deemed too damaged for operational use, what should be done with it? Should it be left behind because it is just another piece of machinery, or should it be made certain that RAS does not fall into enemy possession potentially contributing to technological spill and the destruction of our tactical advantage? Should the RAS self-destruct with the risk of hurting our own people or equipment? Which types of RAS can we leave behind when damaged (wounded) or destroyed (killed)? Does that answer depend on the level of autonomy, lethality, usability, tasks to be performed by RAS? Or does it stem from the technology installed in the RAS and if it can or cannot fall into the opponent's hands? All these questions are important to have answered before RAS is being used in training and operations. Clearly, the change in concepts and doctrine will move from human-centric operations assisted by RAS, towards optimizing man-machine teaming and eventually RAS-centric operations supported (and directed) by humans. The answers to all the above questions will form part of this doctrinal change.

Command & Control

Military operations are very much task- or mission-oriented, whereby individual soldiers must have the ability to perform the mission according to the commands he received from a higher authority. In an operational military environment, these commands will be given according to a certain set of rules, regulations, and vocabulary. At the same time, the soldier must be able to adapt to changing operational environmental circumstances and still reach the desired effect and complete the task. Even when—or especially when—he is unable to reach a higher level of command for guidance in these new circumstances. Therefore, while on the one hand, military operations require discipline to follow orders (a core military virtue), on the other hand flexibility of mind and creativity of the individual is required.

One might argue that concerning the required discipline on one side and the needed flexibility and creativity on the other, RAS will likely be difficult to integrate within the military on anything more than just 'dull', 'dirty' and 'dangerous' tasks. Indeed, this is where the first application of RAS within the military will take place. They will alleviate foot soldiers hard work (e.g., packbots) or take care of navigation, thus reducing the strain and fatigue on the soldiers and allowing them to be more focused on warfighting. Such a relatively simple task will already require special skills from RAS. They should be near, following the soldiers without hindering them and be as silent as possible. Escort systems must be able to hide and run when the soldiers do. RAS should be as independent as possible, operate with minimal commands, and yet be a reliable partner. It is debatable whether these skills require a form of AI installed in the RAS, or if smart programming will provide all needed capabilities and operating modes. But as indicated

earlier in this paper, once RAS have proven their added value, the amount of RAS will increase as well as their tasks and utilities. Obviously, more complex tasks require more 'intelligence' in the RAS.

Humans and RAS excel at different cognitive tasks. Close attention should be given to how RAS will gradually take over human tasks, without degrading the number of considerations humans have in their decision-making and task execution. Especially in situations where human life is at risk and International Humanitarian Law comes into play, we are still reluctant to allow AI to make independent decisions although, in practice, AI is already widely used for relatively simple and harmless tasks. The operator for less autonomous RAS likely is in a safe environment (for example MQ-9 operators), has Reachback to all kinds of supportive systems and can confer with colleagues and leaders about decisions to take. In such a case it might improve the quality of these decisions and make them considerably more thought-through than those taken in the heat of battle. Furthermore, they do not get tired or distracted and can perform tedious tasks without losing concentration and focus. Decision-making here is based on algorithms and lines of programming, which in principle does not falter. When decisions taken by RAS are based on imagery and visual recognition techniques and patterns, there is no human 'filter' in place to make unsubstantiated deductions. When RAS can make use of deadly force, the ethical debate concerning Meaningful Human Control (MHC) comes into play.[2] Noteworthy is the discussion about Meaningful Human Control, Human responsibility, and Accountability.

Soldiers will use (deadly) violence in war according to a prior set of rules made often by politicians as the Rules of Engagement (ROE's). These guide the decision-making for the use of weapons without the need to ask for permission every time a soldier feels it necessary to use lethal force. Without reiterating the debate on MHC, one might argue that when ROE's are instilled in RAS software, and kept up to date, that this is also a form of MHC. ROE in the C2 system of RAS might become a way to guarantee HMC in autonomous systems. Command and control are also a two-way street. A command is given and received, the receiver should study the task given and report back if and how they will perform the task, what they need to complete it and sometimes what they expect from others to execute it. After the action, a report should be given to the higher echelon about completion of the task, mission effectiveness and peculiarities, if any. Another question arises on how C2 will be conducted in future when intelligent RAS will make up a serious amount of the military inventory. Thinking further ahead, will there be levels of command between RAS, are there any boss-RAS and subordinate ones, can RAS in certain circumstances 'command' humans? Basic throughout the use of RAS will have to be that they are relatively resilient to cyberattacks and thus for instance cannot be turned (by the opponent) against the employer of the RAS.

[2] See Esther Chavannes and Amit Arkhipov-Goyal, "Towards Responsible Autonomy," The Ethics of Robotic and Autonomous Systems in a Military Context (The Hague: The Hague Centre for Strategic Studies, September 2019), https://hcss.nl/sites/default/files/files/reports/Towards%20Responsible%20Autonomy%20-%20The%20Ethics%20of%20RAS%20in%20a%20Military%20Context.pdf.

5.3 Line 3: Legal and Normative frameworks and Public Support

The application of RAS will be constraint by issues of ethics, proliferation, laws and regulations, public understanding, and support.

The use or potential use of RAS has been at the forefront of discussion in the public sphere. On one side of the debate, RAS are sometimes framed as 'killer robots' with the associated risks stemming from the combination of autonomy and weaponry are highlighted, thus narrowing debate to autonomous weapons systems and drawing away from the vast, non-lethal applications of RAS. The other side of the debate emphasizes the potentially critical role of RAS in gaining competitive advantage in conflicts during an era where the character of warfare is rapidly transforming. This complex debate requires deep thinking on (future) ethical implications but must be grounded in the reality of the conflict environment around us (and ahead of us) and the vast opportunities available for RAS implementation across numerous military application areas.

TNO's thinking on this and their development of algorithms such as Goal Function and World Model is a promising approach. RAS, for one thing, will not always be equipped with lethal or less than lethal weapon systems. In the case of the latter, will an ethical decision on employing such systems in a military operation be necessary or even be of any added value? Will such systems be subject to the Wassenaar agreement on arms sales? Will it be necessary to make these systems subject to the Convention on Certain types of Conventional Weapons, or are they weapon(systems) at all? And when RAS are armed (e.g., an MQ9 with Hellfire missiles) does this make it automatically into an autonomous killer drone as long as the decision to fire the missile is made by humans and still done based upon acquired intelligence? The fact that the weapon system itself acquires footage which forms the basis for the decision to apply force executed by the weapon system still does not make it a killer robot. For example, a modern Sidewinder missile fired by a pilot in an air-to-air conflict acquires its target after being cued towards it and follows it and deploys its autonomous sensor to decide the best point of impact or explosion as well as taking into account evasive maneuvers and tactics such as flares in order to achieve the desired effect. In the case of the Reaper Drone armed with Hellfires, it is nothing more than a very concise sensor-to-shooter loop, built especially for time sensitive targets. It seems that new norms, descriptions and taxonomies are required and should be established in order to structure valuable debates and to make the debates worthwhile when they concern the bigger issues such aa life or death decisions.

One might state that the developing knowledge and possibilities of autonomy offer avenues to incorporate our ethical system and moral considerations within the decision-making of the 'robot'. Presently, face-recognition is not highly advanced nor faultless, but that will change with time. What will incorporating such technology and coupling it with reconnaissance mean for our military capabilities and our view on its application? Further investigation on such developments is a worthwhile pursuit as it could lead to new thinking and legislation concerning the use of AI under certain circumstances.

As for proliferation, one might say that the rules for export control could be applicable. Highly advanced technological knowledge and systems only have the competitive advantage as long as they are confined to one party. And as long as that party is adhering to IHL and subsequent legislation there should not be any restrictions on the use of these kinds of systems.

Public and political support are essential. Clear communication and well led debate is critical to bring home the message that one should not run away from this difficult task and that support is required to further experimentation and use.

5.4 Line 4: Organization and Leadership

The organization is not yet ready to fully adapt to RAS, the concept of units as they are known by tradition is less relevant and needs rethinking.

Operating with RAS introduces many challenges as described above, with issues needing to be teased out, developed, and implemented. Without strong and visionary leadership and a motivated and forward-thinking organization, this task will be near impossible. In numerous fields, not only new concepts, doctrine, training, and logistics have to be thought through, but also future applications and needs have to be defined. One of the first questions to arise will be the number of RAS needed for certain tasks and military missions. Will RAS be added at a group, platoon or company level? How much RAS will units possess, at platoon and company level, or at HQ level? This will fully depend on its military tasks and what the specific RAS is developed for. However, 'orders of battle' have to be defined and figures have to be given at a certain point in time These kinds of questions will guide developers and producers of RAS and will determine prices (for purchase, lease or using the capabilities).

In order to gain knowledge in this field, the RNLA is already experimenting with different types of RAS. The assigned experimentation unit is free to experiment and gain knowledge on RAS in the broadest sense. This kind of freedom within an organization is a prerequisite to gain essential knowledge on all issues raised. At the same time, a display of leadership attitude is much needed, especially when on the forefront of such revolutionary means such as RAS and AI. At the same time, workshops focused on widening knowledge and diving deeper into such questions as stated here will help designing the (RAS-) units of the future.

When entering the RAS era, developments will accelerate. Once the positive sides of working with and alongside RAS have been proven and showcased, the hunger for more RAS will probably increase. The following questions arise regarding the organization of RAS:

- *How to organize the increasing use and dependency on RAS?*
- *Who has control of this momentum, the technician or the commander?*
- *How to organize distributing tasks and commands to RAS?*
- *How to combine the strong points of RAS and humans in training and in life threatening war-fighting ops?*
- *Will we still conduct 'train as you fight' doctrines?*
- *Introducing RAS requires a change of culture, how does leadership foster this change?*

Here, true leadership must be shown enough reign to allow for experimentation far beyond the 'normal' working arena (again, what is normal when working with RAS?), but, simultaneously, reaping the yield of what has been achieved and transferring it into concrete projects and needs.

Human Talent and Training

Training in military environments serves a purpose. It instills discipline, but mainly it provides proficiency and skills in a benign environment which can then be implemented in volatile, and sometimes life-endangering situations. Training is conducted mostly through a step-up program, beginning with individual military skills, developing to work in small groups, to operations at unit level, to integration within a bigger system, and eventually at the level of a fighting force. With the introduction of RAS, the dimension of training will have to adapt to these systems as well. Questions arise on the set-up of training and how to integrate these new systems with their concepts and doctrines:

- *Will training have to be changed or adapted for RAS to maintain the same level and intensity of 'conventional' training?*
- *How can we fit RAS within the training system? Will it be necessary to train as intensively with RAS as it is without them?*
- *If RAS take up the entire fighting force, do we still need training at the highest and most challenging level for humans?*
- *Will the use of RAS lead to risk avoiding behavior within humans ("why sacrifice myself for a robot?")?*
- *How should human personnel cooperate with RAS, will RAS be considered buddies, threats, assistants, subordinates, or superiors?*
- *And what does that mean for training? How do we train for cooperation with RAS in all above levels of hierarchy? How far do we trust RAS to take up certain tasks?*
- *and vice-versa, do RAS trust the quality of decision making and guidance by humans?*

As this is uncharted territory, the optimal way to find answers on above questions is a careful experimental approach. However, with rapidly developing technology (think of Moore's law), evolutions within RAS and AI might dictate the tempo and leave no room for a 'crawl-walk-run' approach on training. As RAS do not suffer from fatigue and have unending stamina, thinking needs to be done on what this means for teaming up with personnel who have physical limitations. Is it possible for RAS understand these human limitations and take them into account?

When RAS are not used in training, exercises or operations, they must be stored somewhere. Preferably, this storage should be conditioned to prevent RAS from unnecessary exposure to excessive rain, humidity, sun and extreme weather conditions. What are the infrastructural challenges and standards for storing RAS when not deployed/used in training and is specific infrastructure needed for repair and maintenance?

Perhaps not every training with RAS takes place outside. There might be cases when training inside is required or when training exercises take place indoors with the help of Virtual or Augmented Reality techniques. For reasons of Operational Security (OpSec), training must be shielded from outside observers, be it from space, from the

air or from the surface of the earth. In such a case, terrain that is closed-off and covered must be available. It follows that the introduction of RAS can easily have infrastructural implications. Further research must be done if special infrastructure must be built and if extra equipment must be acquired.

In order to transport RAS between exercise and operation locations and the places where they are sheltered, they must move or be moved. Some RAS will fit into trucks and can be transported as normal cargo, while other RAS are self-driving or self-flying. We must consider that RAS will frequently use public roads, or move through the air, in/across the water. For all these environments traffic rules apply. That means that RAS will have to be certified for use through the public domain as well. A form of certification will have to take place before RAS can be introduced as military inventory.

In the military, training and proficiency in tasks often lead to increasing competencies, better performances and increasing career chances. This leads to important questions on the implementation of RAS on careers and training:

- W*hat if essential military manual labor is not conducted by personnel anymore, will they still be able to build their basic skills, or will the set of basic skills completely disappear?*
- *What does this mean for career possibilities?*
- *Do personnel have to be selected for working with RAS, can everybody work with RAS, or does it require extra skills and qualifications?*
- *How do soldiers acquire these skills, will the introduction of RAS lead to the need for a different type of soldier eventually?*

All of these questions will require answers before work with RAS can commence but can only be truly answered whilst working with RAS. Every type of RAS will require its own set of challenges, dilemmas and procedures when they are integrated into working with humans. The man-machine teaming concepts of 'loyal wingmen', 'flocking' and 'swarming' will have to be defined for each type of RAS, mission, and task. It is likely that over time, more definitions and hybrid forms of man-machine teaming will be developed. Depending on certain missions and surrounding circumstances, the concepts can be switched, either temporarily or situationally. Significant flexibility will be required of the soldiers that work with RAS and the operational concepts that come with working them. Special selection criteria probably will have to apply to attract the right kind of qualified personnel.

Logistics and infrastructure

All military equipment must be serviced or repaired occasionally. Independent of the discussion on ownership, the materiel will occasionally be unserviceable, out of order, under repair or under further development. Additionally, the provision of upgrades for either the hardware or the software renders equipment unavailable for certain periods of time. Just as with conventional equipment, there will have to be enough operational systems to continue training and missions alongside planned and unplanned maintenance. Hardware and software maintenance, in principle, do not require specific logistic challenges for a military organization. There are examples that new dimensions are introduced in RAS, one being automatic software upgrades (for example, Tesla and

its electric powered cars). How do the military keep check on the software updates, and how much does the updated software still comply to the set ROE? Do RAS still perform in the same way, with the same commands? Have they become 'smarter' by a software update, and what does that mean for procedures, tasks, doctrine and interoperability with other RAS and humans? What further complicates these questions is when RAS are equipped with self-learning software. In this case, updates and improvements are introduced incrementally and almost continually and perhaps even without knowledge of the operator. A system of quality control will have to be implemented within the organization to keep track of enhanced software, improved capabilities, and related (interoperability) issues, like compliance with ROE for example.

Furthermore, within logistical processes, the maintenance interval is often important. The amount of 'flying hours' or operating hours for RAS before depletion will decide the availability of these systems. With the use of big data for logistical support and life-cycle maintenance, the period of time when RAS can be in use can be better scheduled, leading to optimal use of available time and systems. Battle damage repair is another issue to be explored. Depending on the damage, RAS, like any other equipment, is classified as either destroyed or repairable. Moreover, the threshold of damage to RAS that can be sustained before the system should be withdrawn needs to be prescribed. This is critical to the prevention of destruction or capture of potentially sensitive technologies. But to which level of repairable state RAS can be managed in the field or not, must be prescribed. Certain RAS systems can contain either sensitive information or technology or both, which must be salvaged in case of damage, destruction or capture so that it does not fall into the opponents' hands.

RAS require other logistical processes than human-centric solutions, are tasked differently, have different operating cycles, and require different modes of learning. Initially, RAS will likely function as complementary to human operators as part of what will for the time being remain human-centric solutions. Eventually, as RAS mature and armed forces become more familiar with RAS, dedicated RAS-centric solutions will be sought out and found. This will likely imply not only the adaptation of existing human-centric processes and structures (in evolutionary, incremental steps), but also the transformation process, for them to fit into the peculiarities of RAS (in rapid, potentially precarious leaps).

6 Conclusion

Before multiple RAS applications can be effectively applied to the military toolbox, extensive thinking about numerous peculiarities specific to the military must be conducted. In some instances, thinking has to precede the decision making, while in others, decision making cannot be done without practical experiences and experimentation. The former is already taking place, albeit on a small scale. This paper addresses additional viewpoints and questions to carefully consider during the process of acquiring increasing numbers of RAS. At the same time, the questions and the issues raised here are far from complete. The best way forward is to experiment and learn at the same time and to learn simultaneously and continuously.

Based on our assessments, several actions required for the implementation of RAS, were identified and addressed in the lines of development. This could serve as a point of departure when thinking about the implementation of RAS in the armed forces.

The questions explored in this paper will assist in attaining a firmer hold on RAS issues as we venture into uncharted territory. Overall, there is only one way forward in modern warfighting, and that will involve an increased use of RAS and the accompanying AI. It is up to decision makers to make this path as smooth and complete as possible by enhancing the benefits of this technology and addressing the risks and challenges.