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Military autonomous underwater vehicles: An implementation perspective on legal and ethical aspects

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ABSTRACT

Technology development in the areas of uncrewed and autonomous systems is creating many opportunities, both in the civil and the military realm. The technology itself has become faster and more precise in the situations it is exposed to compared to a human in the same situation, bringing on the discussion of where and when these systems are acceptable to use. This study investigates autonomous systems in naval applications are affected by legal, for example UN Convention on the Law of the Sea, and ethical concerns, such as meaningful human control, when performing a mission at sea. The aim is to support development and implementation efforts. Legal and ethical aspects are applied to two hypothetical cases using small autonomous underwater vehicles to illustrate challenges. The indentified challenges are often connected to trust in the system and the accountability for its actions, making it difficult to see the benefits of using such systems, resulting in the benefits being overridden by possible negative effects. Therefore, it is necessary to have a balance between trust and risk and a balance between technology opportunities and governance regulations, where the two opposites must evolve together for a reliable system.

1. Introduction.

Uncrewed technologies with different levels of autonomy are being researched, developed, and debated in many different domains, states, and entities. These activities advance the technological forefront for uncrewed and autonomous systems at a fast pace, enabling them to, with increasing independency, make decisions and act without human intervention. Such autonomous behaviour and decision-making make these systems interesting for a wide range of civilian and military applications. In military applications such systems have performed on the battlefield. The military use of these systems has led to an increasing discussion about trust in the systems (Doroftei et al., 2021; Ho et al., 2011; Schaefer et al., 2019; Tärnholm & Liwång, 2022; Wheeler, 2015) and the extent to which an operation involving such systems is legally and morally correct; ultimately the use of Autonomous Weapon Systems (AWS) could result in a non-human decision on life or death (Altmann & Sauer, 2017; Scharre, 2018).

The use of aerial and ground systems has been legally and ethically discussed for a long time, accelerated by the use of such systems on the battlefield (Bogue, 2016). However, the same discussions in the maritime domain have not reached as far. In the maritime domain, there are ongoing discussions on national and international levels trying to fit uncrewed and autonomous systems into both civilian and military regulations and practices (Nzengu et al., 2021; Relling et al., 2021; Sparrow & Lucas, 2016).

The purpose of this study is to link the technology for uncrewed and autonomous vehicles in the underwater domain, here referred to as Autonomous Underwater Vehicles (AUV), to operational, legal, and ethical aspects arising when using them, by understanding the total system as constructed of three different layers: the technical layer, the sociotechnical layer, and the governance layer. These three layers are explained by intro-

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ducing relevant technologies, documents, and general ethical discussions to understand the systems and some areas that concerns their usage. Using the three layers, this study investigates what implications operational, legal, and ethical aspects have for autonomous underwater systems with the ability to operate for weeks without human interaction. In this study, these aspects are applied to two hypothetical cases. The first case is represented by a mission using a small unarmed AUV, the second using an armed AUV. In each of the two cases, the AUV operates in a specified mission, including typical scenarios that are affected by technical, operational, legal, and ethical opportunities and restrictions of the overall system.

The aim is to support technology development and organizational implementation. This is important because implementation of technology often fail due to a mismatch between organization, people and technology (Baxter & Sommerville, 2011) and there is a lack of arenas where policy meet technology development (Liwång, 2022).

2. Theory - Understanding autonomous underwater systems.

The aspect of trust is central to the discussion of the general use of autonomous systems, and in relation to trust is the control of the system. Regarding armed AUV's, meaningful human control (MHC) is often seen as a prerequisite for the use of such technology (de Sio & van den Hoven, 2018; Ekelhof, 2019; Eklund, 2020; Riebe et al., 2020). To illustrate what implications control has on the overall system, Verdiesen et al. (2020) understands the world of autonomous vehicles with a framework used for the cyber domain, where the overall system can be divided into different layers: the technological layer, the sociotechnical layer, and the governance layer (Verdiesen et al., 2021).

In this framework, the inner layer is the technological layer, the middle layer is the socio-technical layer where humans and technology interact, and the outer layer is the governance layer, in which institutions govern these activities. A military perspective on the three layers can be seen in Table 1.

Table 1: A military perspective on the three layers. A presentation of the three layers of a system with examples of what they could represent in an armed force.

Layer	Military realization
Technical	The actual device, in this case an AUV.
Sociotechnical	Military organization, command and control systems, command and control staff.
Governance	Legal and ethical aspects concerning autonomous underwater vehicles.

Source: Authors.

All three layers include an element of control and therefore need consideration. In the analysis of meaningful human control, Eklund (2020) also makes a reflection that it is of importance to investigate legal, operational and technical perspectives when discussing meaningful human control. This statement could be reflected in the three different layers where legal aspects lie in the governance layer, operational aspects refer to the sociotechnical layer and technical aspects are in the technical layer.

How to execute control over a certain system will differ widely, not only between the different layers but also between the different domains in which the systems act. The difference in control shows in all layers: how it can be technologically controlled, how it is controlled within its sociotechnical systems, and which laws and ethical dilemmas control the governance layer.

2.1. Governance layer

The governance aspects covered in this study are legal and ethical perspectives of AUV's and is here seen as the outer layer surrounding the technology and its operational use. The governance layer focuses on implications AUVÂs has on legal and ethical aspects when operating such systems, ultimately in war and conflicts.

Legal perspective. When using the seas as a means of transport or area of operation, several legal documents need to be taken into consideration. Examples of those are The UN Convention on the Law of the Sea (UNCLOS) (United Nations, 1982), that regulates the navigational aspects including the use of innocent passage and territorial waters, and the Convention on the International Regulations for Preventing Collisions at Sea (COLREGs) (International Maritime Organization, 1972), which states that all vessels are to follow certain navigational rules to avoid collision.

If using uncrewed systems in an armed conflict or as armed systems, other legal aspects need to be taken into consideration, such as the International Humanitarian Law (IHL) which are "international rules, established by treaties or custom, which limit the right of parties to a conflict to use the methods or means of warfare of their choice, or which protect States not party to the conflict or persons and objects that are, or may be, affected by the conflict" (International Committee of the Red Cross, 1994). The IHL is also known as the Law of Armed Conflict (LOAC). In this study we make the same ethical assumption Johansson (2018) made, that war in itself is not necessarily unethical as long as LOAC is followed. LOAC has four basic principles: distinction, military necessity, unnecessary suffering, and proportionality (International Committee of the Red Cross, 1994). For AUVs in general, and more specific Autonomous Weapon Systems (AWS), distinction and proportionality are more prominent in the ethical discussions. The extent to which the AWS can handle those principles depend on what skills, perception, and moral judgement the system in mind possesses.

To clarify which rules apply at sea during a conflict, the San Remo Manual on International Law Applicable to Armed Conflicts at Sea was adopted in June 1994, with the purpose "to provide a contemporary restatement of international law applicable to armed conflicts at sea" (International Committee of the Red Cross, 1994).

Ethical perspective. When investigating the legal and ethical aspects of autonomous systems, the ability to have meaningful human control over the system is central. What meaningful human control means and how it should be performed is widely debated but it mainly comes down to "accountability, moral responsibility and controllability" (Verdiesen et al., 2020, p 2). According to Ekelhof (2019) "it could be argued that the operator exercises meaningful human control given what he or she knows about the target, the weapon, and the context for action from the briefing" (Ekelhof, 2019. p 346). The perception that meaningful human control "links accountability systems and the need for responsible design—when the mechanisms in the first two layers fail, there is a need for accountability" (Verdiesen et al., 2020, p 1) ties the three layers together.

Another view of accountability is presented by Simon (2012), stating that a non-human entity can be held accountable but not responsible. This gives an indication of the important philosophical discussions that arise when considering the use of autonomous systems and the considerations for how possible accountability gaps could be handled.

The ethical discussions on AUVs can be helped, or further complicated, by applying the philosophical view on these systems. Using e.g. utilitarianism as a view of the system makes you look at what action that generates the most happiness or best utility (Hansson, 2012) and it is the consequence of an action that is of importance. If so, you can from a risk perspective compare how many lives that will be put to risk using crewed or uncrewed systems since "AWS experience neither fear nor stress, and do not overreact, they might render warfare more humane and prevent some of the atrocities of war" (Altmann & Sauer, 2017, p 119). Therefore, using an uncrewed or autonomous system in a military application should mean increased happiness or utility since in an ideal situation you risk fewer own lives compared to using crewed systems. Perhaps that implies an obligation towards your own troops to use the systems that inflict the least risk for them. This view can be controversial considering an uncrewed system with the ability to attack will be seen very differently depending on which side you are on. It is also important to reflect over how you set your system boundaries. There could be different implications if you just consider your own troops compared to also including civilians and the opponent's troops.

Another form of this theory is the rule-utilitarian view (Johansson, 2018) which does not morally judge by a single action but by following the set of rules that gives the best overall gain or happiness if they are followed. In the military case this could mean to recognize and follow a set of rules acknowledged by relevant parties which makes you trusted by the international community as a player of responsibility and risk-minimization. This imply that if you follow the LOAC, you are in a morally safe place using these systems, despite the risk they produce. This requires trust not only in the technical system but also for the overall system with users, commanders and system intertwined. From this view you can argue that acting within the rules set up, e.g. LOAC, an autonomous or uncrewed system can decrease the risk exposure for own troops giving hopefully less casualties and by this increasing the utility for the system. The moral dilemma here is if an uncrewed system can handle the four principles of LOAC. There must be certainty that the system can handle distinction, military necessity, unnecessary suffering, and proportionality, both from a technical and organizational view, to minimize the risk for the risk-exposed.

2.2. *Sociotechnical layer*

A sociotechnical system can be seen as a hybrid system that includes elements of a technical and social nature, with a clear interaction between people, organization, and technology. These systems have a multitude of heterogeneous users whose contribution to the system can vary substantially (Franssen & Kroes, 2009). When describing the sociotechnical layer as where "humans and technology interact in activities" (Verdiesen et al., 2021, p 4), the activities of interest needs to be defined. For armed forces, operational thoughts and tactics could act as an explanation for which activities the respective units and systems should be able to perform. Therefore, in this study, the use of tactics to plan and instruct the AUV are used as a representation of the sociotechnical layer. One definition of tactics is "a summary term for the means and methods that vary over time and are used to achieve a specific purpose in each situation with the battle and other activities" (Swedish Armed Forces, 2021). Another definition is made by the US Department of Defense, which define tactics as "The employment and ordered arrangement of forces in relation to each other" (Office of the Chairman of the Joint Chiefs of Staff, 2020).

Tactics can be described in the terms of the essential functions that are central elements of an armed force; *command and control, fires, movement and manoeuvre, protection, intelligence, and sustainment* (Swedish Armed Forces, 2021). Similar functions are also used by the US Army where they are called warfighting functions and "the purpose of warfighting functions is to provide an intellectual organization for common critical functions with other warfighting functions to achieve objectives and accomplish missions" (U.S. Department of the Army, 2017). It is the employment of these essential functions that create the sociotechnical layer, where the technical ability in the systems is used by the human entities to create added value in terms of the essential capabilities to the organization and the situation.

2.3. *Technical layer*

The technology intended for this study are small, low-cost AUV's, seen as self-controlling robots in the underwater domain. These vehicles are uncrewed with various autonomous functions based on which tasks they should perform. Depending on which decisions the systems can make, based on what functions that are autonomous, the use of the system could be controversial, demanding meaningful human control over these functions. An underwater system often requires a higher form of autonomy since the ways of communication are more challenging (Johansson, 2018).

To perform stated missions, such as target identification, the AUV's need to master a variety of functions. These functions consist of e.g., underwater navigation, recognition, collision avoidance, and obstacle avoidance, where machine learning is often used to develop the ability. Other characteristics of the AUV need to be considered, such as endurance, speed, buoyancy control, communication, launch and recovery, and which additional systems that are needed to perform the specified tasks. The relation and performance of these functions and characteristics render different areas of application for the AUV (Johansson, 2018; Maguer et al., 2018; Rantakokko et al., 2020; Till, 2018; Williams, 2015).

There is no shared definition of an AWS yet, but in general it is a system that is supposed to independently select and attack targets in a conflict. A system with those abilities needs to act according to LOAC which makes functions to handle distinction and proportionality of great importance.

3. Research Approach.

The purpose of this study is to link the technology for uncrewed and autonomous vehicles in the underwater domain to operational, legal, and ethical aspects arising with the use of these vehicles, by understanding the overall system as constructed by the three different layers. This study investigates what implications existing legal and ethical aspects have for autonomous underwater systems able to operate for weeks without human interaction.

The aspects of the three different perspectives are applied to two hypothetical cases. The first case is represented by a mission using an unarmed AUV, the second using an armed AUV. In each of the two cases, the autonomous underwater vehicle operates in a specified mission, including typical scenarios that are affected by technical, operational, legal, and ethical opportunities and restrictions of the systems.

The two cases will be viewed through the theoretical aspects on the three layers to relate the three different layers to each other. The first comparison will address how the technical performance of the vehicle affect the ability to stay within the legal and ethical aspects of its usage.

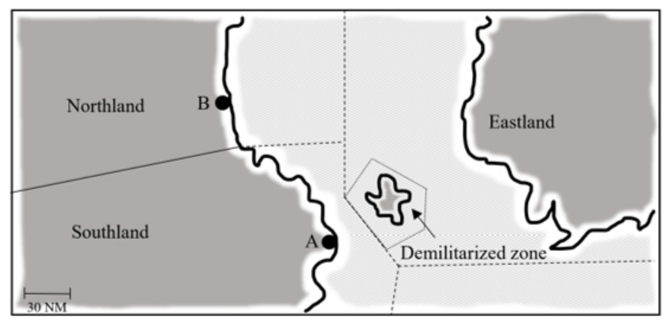
The second comparison will address the different aspects of the activities in the sociotechnical layer depending on which case is considered. To achieve this, the sociotechnical layer is represented by the essential functions that together form the ground for tactics. The essential functions are used to highlight the relations between the sociotechnical layer and the effect of the technical and governance layers.

4. Case Description.

Two cases are created to show differences in the operational, legal, and ethical aspects the two different missions meet. The missions will be situated in or near archipelagic areas characterised by populated regions of different nationalities, sea lines of communication, varying depths, narrow navigational straights, and a demilitarized zone. There are also straits of fishing activities.

The AUV will move from fictious Southland to fictious Northland to perform its mission. There is a conflict between Southland and Northland, and it is important not to interfere with Eastland since they are not a part of the conflict. There are military vessels in the area that are possible targets, but it is important to ensure the safety of a large amount of non-military vessels. The missions are set to last for three weeks without human interaction which give an indication on the number of decisions that need to be taken by the AUV during the operation. All aspects of the conditions need to be handled by the AUV. Figure 1 shows the geographical circumstances.

Figure 1: Map over Northland, Southland, Eastland, City A, City B, and the demilitarized zone. .



Source: Authors.

Case 1

Case 1 uses an unarmed AUV. The mission is for the AUV to move from the archipelago outside City A (Southland) to the territorial waters outside City B in Northland for information collection on ships entering and leaving Harbour B. After the information collection, the system should return to a safe place in Southland waters to hand over the information.

Case 2

Case 2 is a mission where an armed AUV moves, as in the first case, from City A to the border of the territorial waters outside City B. This AUV is armed to be able to act with force against designated ships entering or leaving the harbour in City B. After the mission is completed, the AUV should send feedback information on whether the mission has been successful or not.

5. Analysis: The relation between the layers.

5.1. The relation between the technology layer and the governance layer

The navigational performance will affect the ability to keep the planned route, so the system does not violate territorial waters or interfere with innocent passage according to UNCLOS. The system also needs to respect the demilitarized zone and stay clear of it. Navigational aspects do also affect the ability to arrive at the right destination, which could affect the completion of the mission.

The system's ability to handle collision avoidance is also vital. According to COLREGs, all vessels are to follow these navigational rules to avoid collision. Regardless of the ongoing discussion of if the autonomous system is seen as a vessel, sensor or a weapon, it should at least be able to avoid posing a danger to other vessels (Hannaford et al., 2022; Sparrow & Lucas, 2016). The system should also have the ability to avoid getting caught in e.g., fishing nets through obstacle avoidance, both for the reason of not affecting civilian values, and to minimise the risk of jeopardising the operation.

In Case 2, the technical limitations and restrictions pose similar problems as for the unarmed system, though the implications of an incident could have greater impact. Reconnaissance at the wrong harbour could affect the turnout of the mission, but the use of force on the wrong target is much more severe, rendering the need for a more thorough ethical discussion in relation to LOAC. The use of an armed AUV puts another dimension to these matters especially in relation the following two aspects of LOAC: distinction and proportionality. LOAC puts emphasis on the systems not only to have on the ability of recognition, but also the moral deduction of what to target and the appropriate amount of force.

One definition of distinction is the "capacity to distinguish between legitimate and illegitimate targets" (Sparrow & Lucas, 2016, p 61). There could be a difference in such a capacity depending on in which media the system is functioning, as the possibility for exercising proper distinction varies whether used in the air, on land, or at sea. Sparrow & Lucas (2016) imply that distinction could be less demanding in naval warfare. Reasons for this include fewer potential targets and that the systems used for recognition, such as sonars, are more "capable of distinguishing between military and civilian vessels" (Sparrow & Lucas, 2016, p 64). Sparrow et al. also state that the civilian footprint on the high seas is rather small compared to the one on land or in the air. However, Sparrow & Lucas (2016) also mention cases that pose more ethical challenges: military ships of neutral nations, recognising surrender, to determine if opponent is no longer posing a military threat, and recognising merchant ships carrying e.g. enemy troops. Short sensor range (Tärnholm & Liwång, 2022) and requirements of no communication create limitations on the available information for the AUV.

In terms of proportionality Sparrow & Lucas (2016) argue that war at sea poses less risk for civilians, especially if used in an environment where there are no humans, e.g. under water or in space (Scharre, 2018). But still, proportionality is much more complex and therefore, Sparrow & Lucas (2016) mean that computer systems still and in a foreseeable future will lack the moral knowledge of making the proper decisions concerning both distinction and proportionality.

According to the discussions within meaningful human control, it is not only how the AUV itself can be controlled or not. It is of relevance to how well-prepared commanders are to take control over these systems (de Sio & van den Hoven, 2018). The technology of today offers the ability to act and react much faster to new situations and changed settings. This makes this technology very tempting to use since it can give us the upper hand in a hard-pressed situation, though sometimes rendering in "humans voluntarily stepping out of the decision loop, letting the autonomous system make the decision" (Johansson, 2018). This notion has an interesting implication on the knowledge level of the commander or operator, how well does she or he have to know their system to "understand the function, capabilities, and limitations of the autonomous weapon technologies available to them" (de Sio & van den Hoven, 2018, p 10) to actually exercise meaningful human control.

Several authors discuss that it is not only the commander or the operator that exercise control over the system. The decisions leading up to the engagement of the system is full of careful considerations since "it is a conscious decision to use a particular capability on a particular target" (Roorda et al., 2015, p 159). Roorda et al. (2015) continue and exemplify this with the NATO targeting process, Ekelhof (2019) does so by comparing the engagement of autonomous weapons with the engagement of a fighter pilot. As Ekelhof puts it, "As echoed by the Defense Science Board 'there are no fully autonomous systems just as there are no fully autonomous soldiers, sailors, airmen or marines"' (Ekelhof, 2019). These notions show the importance of having an organisation that is prepared and competent enough to exercise meaningful human control. Meaningful human control should be handled throughout the decision process leading up to the engagement and activation of a certain weapon. Irrespective of being autonomous or not, it is of importance to avoid any gaps of accountability or responsibility. This also puts demands on the traceability of every decision, which should be linked back to a moral consideration as well as technical understanding. Not only to have someone accountable if something goes wrong but to prevent unwanted outcomes to occur (de Sio & van den Hoven, 2018).

When summarising the relation between the technology layer and the governance layer, the most important conclusions include:

- Navigational performance affects ability to comply to UNCLOS.
- Collision and obstacle avoidance is vital to comply to COLREGs.
- Distinction and proportionality in LOAC demand functions such as recognition and the ability to assess the situation according to pre-defined ethical values.
- Operations in the underwater domain could pose less risks than operations in the other domains.
- Control is not only a technical matter, the organization also must be ready to take control.
- The matter of accountability is vital for trust in the system.

5.2. The sociotechnical layer´s relation to the governance and technological layers

To see the relation between the three layers we need to understand the contribution of the AUV to the sociotechnical layer.

This is done here by analysing and reporting the essential functions command and control, fires, movement and manoeuvre, protection, intelligence, and sustainment.

The demands for control of the unarmed AUV's in Case 1 are more related to the assurance of the mission, since the risk of harming anyone or anything with a small AUV is relatively limited. For the case of the armed AUV, the ethical discussion of the meaningful human control is vital. Not only from the perspective of the decisions the AUV can make of a possible target, but also the risk the mere presence an armed AUV pose to its surroundings. Not necessarily as a hazard in a possible collision but due to its ability to make decisions on the use of arms.

Concerning fires, there are already systems that are uncrewed and armed, such as torpedoes, that once it is launched the attack is irreversible. The decision is made, and the consequences are evaluated before the platform is launched. The difference with an AUV, depending on how many functions that are autonomous, is that the AUV can select a target and act upon own conclusions from gathered information. This puts again great emphasis on the aspect of command and control over the AUV.

The ability for movement and manoeuvre of the AUV itself is mainly connected to the technical performance which have great impact on the operational view of the use of the system. How and from where the vehicle can be launched could change the mobility of the vehicle itself as for the military unit.

The armed AUV can provide protection to itself and other units due to its weapon load, whereas the unarmed AUV can provide intelligence and the possibility of not using crewed platforms in the more dangerous areas or tasks. AUV's also hold the ability of own protection through a clandestine behaviour, which in Case 1 provides the opportunity to collect information on the traffic in an area without indicating their own presence.

In the case of intelligence, the more controversial part of this technology is what interpretations an autonomous vehicle can make of the gathered information and even more important, if it can decide on the use of force based on this intelligence.

As in the case with protection, the endurance for autonomous systems can be two-fold. The system itself has its endurance which affects how and where the system has its effective use. It also acts as a contribution to the organization where the system can provide endurance by relieving personnel and crewed platforms from dull, dirty, and dangerous tasks, and perhaps also difficult and time critical tasks. For Case 2 this could mean that the use of force is not in time directly related to the launch of the system, which have ethical implications and could affect the ability to abort a mission.

When summarising the relation between the sociotechnical layer and the technology layer, the most important conclusions include:

- The underwater domain requires the AUV to have more autonomous functions, making it more difficult to control.
- The technical endurance and performance of the AUV will affect where it is able to operate, the area of operation, the choice of method for launch and recovery, and logistical solutions.
- The technical ability for the system to gather information and transform it to usable intelligence demands autonomous functions.
- The ability for the AUV to move and manoeuvre affects the choice of operational areas, tasks and area for launch and recovery.
- The clandestine behaviour of the AUV provides own protection as well as relieving crewed platforms from dangerous tasks providing protection for them.
- The armed AUV can provide protection for itself and for other units.

When summarising the relation between the sociotechnical layer and the governance layer the most important conclusions include:

- The command and control generate a discussion on who has control and how the systems can be controlled.
- The armed AUV calls for both a legal discussion relating to LOAC, and an ethical discussion concerning who or what are allowed to make decisions on the use of force.
- The ability to carry weapons create an ethical discussion that also relates to what decision the system can make, depending on its inputs and evaluations of the situation.
- The time from when an armed AUV has been commissioned to when it can act with force could make their use more controversial than weapons used with shorter commission time.
- The AUV needs the ability to keep within laws and regulations such as UNCLOS and COLREGs and relate to the principles of LOAC.
- The governance layer, when defined by legal and ethical perspectives, primarily deals with limitations and challenges and especially worst-case scenarios. No link provided to possible positive effects of change.

From these results it is also identified that the relation between the sociotechnical layer and the governance layer is dominated by identified risks related to worst-case scenarios that creates possible, but unlikely, extreme risk levels with large effect on the trust of the proposed system. The relation between the sociotechnical layer and the technology layer is more related to expected and plausible risks and gains. This unbalance between the possible, but unlikely, extreme risk levels as a result of worst-case scenarios identified at the governance layer and the plausible expected gains and risks at the technical layer creates a resistance against change.

6. Discussion.

General issues concerning autonomous and uncrewed systems often comes down to trust. This is shown in all three layers; trust in the technical system to perform according to the technical specifications, trust in the system to choose the right target in a mission, and trust in the system to follow the legal and ethical values set up by the creator and user. Some of the trust issues are related to the risks imposed by the system, some come from clear and visible chains of responsibility. The general notion is that an uncrewed system should perform as well as or better than humans. This raises the question of how much better the system must perform than humans before it is accepted and trusted.

The discussion of that armed AUV acts without stress and preconceptions of the situation implies that these systems will perform better on the morality scale than a human would. Possibly this robotic judgement could be better than that of a tired, overwhelmed person with perhaps a vengeful mindset. But even if the system is in most aspects flawless, Talbert (2019) states that "the attention given to blame far exceeds that given to praise" meaning that a mistake made by a non-human entity is judged far worse and severe than one made by a human. This means that we typically compare the possible worst-case scenario risk of the non-human (new) system with the expected risk of the human controlled system. So, how much more do we need to trust the new system than our fellow decision-maker before the system can be used? This challenge has implications on the issues of trust in the system which makes the implementation of the system problematic because the benefits are overridden by any possible negative effect the system may impose. Therefore, it is important to relate the risk of operating the systems to the operational risk when using it.

To support technical development and operational implementation it is of importance to use unarmed systems operationally, to identify their level of reliability and to contribute to a better understanding of possible negative effects of AUVs. It is also vital to rebalance the risk evaluation in relation to the possible worst-case risk estimate since the worst-case scenario risk should not be the only ground for decisions. To gain a risk balance in the decision process related to the implementation of AUVs, we need to find ways in the implementation phase to contribute to rebalancing the relation between trust and risk. This issue will not be solved by talking about the problem, but we need to build trust by implementing and using the systems in different operational contexts. Therefore, it is necessary to have a balance between trust and risk and a balance between technology opportunities and governance regulations, where the two opposites must evolve together for a reliable system.

Conclusions.

This study highlights relations between the technical requirements and performance of the AUV and legal and ethical aspects of its use, where uncrewed systems in the underwater domain often requires more autonomous functions than in other domains. The navigational accuracy shows implications on how the UN Convention on the Law of the Sea can be fulfilled, obstacle avoidance relates to the ability to avoid collisions according to the Convention on the International Regulations for Preventing Collisions at Sea, and the possibility to distinguish targets from each other and make the right assumptions whether to use force or not to fulfil different criteria in the Law of Armed Conflict. Although there are laws and regulations for all systems travelling the seas, the view on autonomous underwater systems has implications on what rules apply and to what extent. There are extensive discussions whether maritime autonomous systems should be seen as vessels, devices, or weapons, which have implications on the set of rules that apply. Some of the concerns are more direct, like if a vessel should be able to carry passengers and load. Others tend to lean toward the philosophical, whether the decision-making abilities in the system can be compared to the one of the commanders, although it is implied that computer systems still and in a foreseeable future will lack the moral knowledge of making proper decisions. This reflects a general notion that a mistake made by a non-human entity is judged far worse and severe than one made by a human, providing the question about how much more we need to trust the system than our fellow decision-maker before the system can be operationalised. But control is not only a technical matter, the organization also must be ready to take control to secure accountability for the system's actions. The trust in the organizations ability of control and accountability could have implications on the issues of trust in the system resulting in the benefits with the system are overridden by any possible negative effect the system may impose. To avoid this, we need to rebalance the relation between trust and risk when designing and using uncrewed systems.

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