Defining Weapon Systems with Autonomy: The Critical Functions in Theory and Practice

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Abstract

The rise of the use of Autonomous Weapon Systems (AWS) in the battlefield has engendered numerous ongoing legal debates, including that on their legal definition. There have been various approaches with respect to defining them in relation to their interaction with humans, the complexity of the technology behind them, and the features of their functions. The latter has been particularly endorsed by the International Committee of the Red Cross (ICRC), which defines AWS as weapon systems with autonomy in their critical functions of target selection and attack. None of these approaches received unanimous approval by States. Though scholars have addressed the advantages and the disadvantages of the first two approaches, not many amendments have been introduced on the functional approach of the ICRC.

The wording of the ICRC definition is vague and requires a framework on what should be defined as critical as well as on the functions of weapon systems. The critical nature of the function must be determined in relation to its relevance in terms of international humanitarian law (IHL) regulating AWS, which is the most important element in their definition. This analysis will benefit to resolve the impasse in the debate on the legal definition of AWS and further the efforts to regulate them.

I. Introduction

The advent of technology, among many things, changed the means of warfare. There is an accelerating impetus for the development and use of weapons with cutting-edge technology that leaves considerably less need for human involvement. This impetus triggered international law efforts to observe, define and regulate these weapons specifically in relation to international humanitarian law. One of the most prominent of these efforts is the Group of Governmental Experts (GGE) on Lethal Autonomous Weapon Systems, established in 2016 under the framework of the Convention on Certain Conventional Weapons (CCW). It has been working on the matter since 2013 and had been condemned for tardiness and futility. Though In 2019, contracting States to the CCW adopted 11 Guiding Principles to which all AWS must adhere on the recommendation of GGE.[1] Still, States and other critical actors have not reached a consensus on the definition of AWS. The problem with establishing the definition of AWS diminishes all the progress in other issues regarding the development and use of these systems. Like the 11 Guiding Principles, the steps taken are mainly in vain as long as they can be circumvented due to the contentiousness surrounding the definition of AWS. This makes it impossible to properly evaluate the new weapons systems being developed, let alone shed light on the existing

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[1] CCW, 'Meeting of the High Contracting Parties to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects' (13–15 November 2019) UN Doc CCW/MSP/2019/9 para 1.

ones. The objective of this paper is to evaluate the different approaches to the legal definition of AWS and refine the existing approach to defining AWS with respect to functions that enjoy autonomy.

In the second section, this paper will serve to reframe the debate on the legal definition of autonomous weapons systems by first evaluating the technical and legal definitions of autonomy, and then, in the third section, elaborating on one of the central notions in this debate; Autonomy in critical functions. Subsequently, a novel Turkish example in the autonomous weapon systems debate, STM-Kargu, will be scrutinized, which recently sparked concern after being cited by the United Nations Security Council Panel of Experts Report as the first Lethal Autonomous Weapon System having launched a fully autonomous attack in Libya.[2]

II. Definition(s) of AWS: An autonomous weapon system or a weapon system with autonomy?

Although there is no universally accepted definition for it,[3] there is relatively less controversy about the definition of a 'weapon'. As an essential tool for the use of force,[4] it is accepted as a means of warfare in international humanitarian law,[5] and can be broadly defined as:

Any device constructed, adapted, or used to kill, harm, disorient, incapacitate, or affect a person's behaviour against their will, or to damage or destroy buildings or materiel[6] which 'acts through the application of kinetic force or of other means, such as the transmission of electricity, the diffusion of chemical substances or biological agents or sound, or the direction of electromagnetic energy…'[7] and 'includes cyber weapons that damage computer systems and networks or result in physical harm to people or objects.[8]

Similarly, 'a weapons system' can be defined as 'a combination of one or more weapons with all related equipment, materials, services, personnel, and means of delivery and deployment (if applicable) required for self-sufficiency'.[9] In more technical terms, carrier and launch platforms,[10] sensors, communication systems, and fire control systems that accompany the weapon in a weapon system to form its ability to engage with the target.[11]

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2 UN Panel of Experts Established pursuant to Security Council Resolution 1973 (2011), 'Letter dated 8 March 2021 from the Panel of Experts on Libya Established pursuant to Resolution 1973 (2011) addressed to the President of the Security Council' (8 March 2021) UN Doc S/2021/229 (UNSC 2021)para 63.

3 Stuart Casey-Maslen, 'Weapons' in Ben Saul and Dapo Akande (eds), *The Oxford Guide to International Humanitarian Law* (OUP 2020) 261, 267.

4 ibid.

5 Marco Sassòli, *International Humanitarian Law: Rules, Controversies, and Solutions to Problems Arising in Warfare* (1st edn, Edward Elgar Publishing 2019) 380; William H Boothby, *Weapons and the Law of Armed Conflict* (2nd edn, OUP 2016) 4; Michael N Schmitt and Jeffrey S Thurnher 'Out of the Loop: Autonomous Weapon Systems and the Law of Armed Conflict' (2013) 4 Harvard National Security Journal 231, 271.

6 Stuart Casey-Maslen, *Weapons Under International Human Rights Law* (Cambridge University Press 2014) xv-xx.

7 ibid.

8 ibid.

9 William C Barker, 'Guideline for Identifying an Information System as a National Security System' (August 2003) National Institute of Standards and Technology Special Publication 800-59 1, 8.

10 For the definition of Weapon Platform, see Vincent Boulanin and Maaike Verbruggen, *Mapping the Development of Autonomy in Weapon Systems* (SIPRI 2017) 124: '*The platform on which a weapon system is mounted (e.g. a combat aircraft on which missiles are mounted).*'

11 ibid.

On the other hand, the term autonomy can mean a variety of things in a myriad of contexts. In linguistic terms, the Greek terms *autos* (self) and nomos (rule) signify a sense of independence.[12] Similarly, in everyday language, it can denote self-reliance[13] as well as a form of freedom to govern itself without external control.[14] The debate on the legal definition of AWS, on the other hand, is heavily influenced by the technical applications of autonomy. A technical perspective is an indispensable step, hence an inescapable source of confusion, to understand the legal problems accompanying the use of AWS. Accordingly, in this chapter, autonomy will be analysed as a technical term. In doing so, efforts will be made to explain the computational science behind autonomy. Then, autonomy in weapons systems will be examined. Subsequently, the existing efforts for a legal definition of AWS will be put through a critical lens to conclude which definition will best suit the exigencies of international law. For this purpose, a detailed analysis of the critical functions of the weapons systems will be made. After all, it is these technical innovations that outpace the evolution of existing norms and thus bring on legal challenges which necessitate defining AWS.

A. Autonomy as a technical phenomenon

Autonomy is the capability to perform some functions or tasks in the real world for a certain time without being controlled from outside.[15] Living organisms[16] such as humans and animals, unlike rocks, are autonomous systems. However, humans also create autonomous non-living systems to perform a specific function or task through the perks of computer programming and engineering. The creator can strictly determine this function or task, but there may be unexpected performance results, especially in complex systems. [17] The autonomy stems from the fact that these systems can make their own decisions[18] when it comes to performing a specific function or task i.e., without human control or supervision[19].

i. The functioning of autonomy

Autonomy is 'a means for transforming data sensed from the environment into purposeful plans and actions'.[20] It is a result of a process of 'observation and perception' of the environment where the machine is located, 'planning' of the actions required according to a pre-programmed model of the environment introduced to the machine, and according to the observations made by the machine, 'execution' of the action independently from a

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12 George J Agich, 'Key Concepts: Autonomy' (1994) 1(4) Philosophy, Psychiatry, & Psychology 267, 267.

13 Jeffrey M. Bradshaw and others, 'The Seven Deadly Myths of "Autonomous System" Human-Centred Computing (2013) 28(3) Intelligent Systems 2, 4-5.

14 'Autonomy, n' (Cambridge Dictionary)<https://dictionary.cambridge.org/dictionary/english/autonomy> accessed 20 March 2022.

15 George A Bekey, *Autonomous Robots: From Biological Inspiration to Implementation and Control* (The MIT Press 2005) 2.

16 ibid.

17 ibid.

18 Maja J Matarić, *The Robotics Primer* (The MIT Press 2007) 2.

19 Merel Ekelhof, 'Human Control in the Targeting Process' in Robin Geiss (ed), *Lethal Autonomous Weapons Systems: Technology, Definition, Ethics, Law & Security* (Federal Foreign Office 2017) 66, 67.

20 David A Mindell, *Our Robots, Ourselves: Robotics and the Myths of Autonomy* (Penguin 2015) 21.

human operator[21] through computer programming apt for interacting with the environment.[22]

An autonomous system has 'sensors' to observe and perceive its environment,[23] 'a control system' to plan and decide on its actions[24] , and 'effectors and actuators' to execute those actions.[25] At the end of this three-layered operation, an autonomous operation is performed. Sensors are a part of the hardware of the autonomous system to collect data about the environment[26] and they are equipped with the software to interpret the collected data into machine terms,[27] i.e., a computational model of the environment is introduced to the autonomous system.

Although there are different types of control systems that allow for the performance of actions to different extents, a control system can be generally thought of as the 'brain' of the autonomous system,[28] equipped with the software algorithms to transform the input of the environment into plans. The software algorithm, which can be thought as sets of mathematical functions prepared by computer programmers, is what allows the system to make a decision. In the roughest of terms, it could be a command function such as 'When you see X, do Y'. In this example, the input is X, and the output is Y. An important technique of algorithmics used in control systems is called 'randomized algorithms'[29] that allow systems to create different outputs under the same input, as in 'When you see X, do anything to attain T', which could have a significant potential to inject unpredictability into the system.[30]

Effectors are the arms and legs of the system to implement the decisions taken by the control system in the real world. In technical terms, effectors provide the ability of locomotion, [31] movement, manipulation, [32] and interaction with the physical environment in order to take actions.

ii. Software of Autonomy: Artificial Intelligence and Machine Learning

Artificial Intelligence (AI) is a set of computational methods.[33] These are studies of complex systems, such as the human mind, through simulations created by computer programming. Likewise, AI has the purpose of mimicking human intelligence[34] to equip the machines with the ability to untangle problems that have been so far only carried out through human intelligence.[35] Although the purpose is mimicking human intelligence, the method of achieving this goal is not via working for the best brain-like organ possible. It is

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21 Dimitri Scheftelowitsch, 'The State of Artificial Intelligence: An Engineer's Perspective on Autonomous Systems' in Vincent Boulanin (ed), *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk* (Stockholm International Peace Research Institute 2019) 26.

22 Boulanin and Verbruggen (n 10) 19.

23 Matarić (n 18), 19.

24 Boulanin and Verbruggen (n 10) 9.

25 Matarić (n 18) 19.

26 ibid 27.

27 Boulanin and Verbruggen (n 10) 8.

28 Matarić (n 18) 26.

29 Boulanin and Verbruggen (n 10) 11.

30 ibid.

31 Matarić (n 18) 27.

32 ibid.

33 International Panel on the Regulation of Autonomous Weapons (IPRAW), *Focus on Computational Methods in The Context of Laws* (German Institute for International and Security Affairs2017) 9.

34 Vincent Boulanin, 'Artificial Intelligence: A Primer' in Vincent Boulanin (ed) *The Impact of Artificial Intelligence on Strategic Stability and Nuclear Risk* (SIPRI 2019) 13.

35 Tobias Vestner and Altea Rossi, 'Legal Reviews of War Algorithms' (2021) 97 International Law Studies 509, 513.

again through computer programming by which machines are taught to deliver results that humans bring thanks to their cognitive abilities. For instance, when a machine recognizes an image, it is because the pixels comprising that image has been previously introduced and it later recognizes the correlation of pixels in subsequent images.[36] Humans in contrast rarely pay attention to pixels when perceiving an image. Thus, AI systems are software programs that allow for the development of machine abilities yielding to human-like outcomes.[37]

General AI is a term used for a complete replica or a better version of human intelligence bestowed with a variety of traits to match a human's perception of the world and is considered more of a science-fiction topic than a near-future reality.[38] Narrow AI is the half-century old reality[39] found today in self-driving cars or voice assistants such as Siri. It has the purpose of AIisation[40] of specific intelligent traits of humans such as but not limited to learning, understanding speech patterns, and recognition of image patterns. In that, machines have a specific task and a particular environment where they operate.[41]

Autonomy is one of the traits of humans than can be the result of AIisation. Moreover, autonomy is an area of application[42] of a specific computer programming technique for AIisation, which is machine learning. In the past, other methods[43] such as hand-coded programming have also been used[44] for AIisation, where human programmers develop software by specifically defining the problems and solutions and introducing these into the system.[45] However, much of the progress in AI today is a result of machine learning.[46] Machine learning is a way of developing software that creates a system with an ability to learn and subsequently initiates a process of teaching the system to solve problems[47] or execute a task.[48] The learning of the machine is not a mirror to the mechanism of human learning, but rather a process where the machine is introduced and goes through a deluge of statistical data to abstract a general model in order to find a solution.[49]

Machine learning is more advantageous than hand-coded programming since it is impossible to predict and completely code encounters and changes in the environment where the machine operates beforehand.[50] Thus, machine learning provides a flexible way

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36 Boulanin (n 34) 20.
37 ibid 14.
38 ibid.
39 ibid.
40 This paper will use the term 'AIisation' to define the process of using AI to develop a human ability in order to correctly depict the meaning and function of AI.
41 Boulanin (n 34) 14.
42 Boulanin (n 34) 15.
43 Stuart J Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach, Global Edition* (4th edn, Pearson 2021) 19.
44 Vestner and Rossi (n 35) 515.
45 Boulanin and Verbruggen (n 10) 16.
46 Vestner and Rossi (n 35) 515; Russel and Norvig (n 43) 7.
47 Boulanin and Verbruggen (n 10) 16.
48 Michael Copeland, 'What's the Difference Between Artificial Intelligence, Machine Learning and Deep Learning?' (*NVIDIA*,29 July 2016) <https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/ > accessed 23 August 2021.
49 Russell and Norvig (n 43) 669; Christoph Molnar, *Interpretable Machine Learning* (Lean Publishing 2021) 18.
50 Russell and Norvig (n 43) 693.

of managing ever-incoming data to improve itself.[51] Also, some tasks and environments may be too difficult to program, for instance when the task is executed by humans through intuition.[52] However, this performance advantage of machine learning comes with the cost of losing track of the algorithm that allows the machine to reach a conclusion.[53] Contemporary uses of machine learning creates a 'black box', which is 'a system that does not reveal its internal mechanisms'.[54] This is primarily due to the fact that as the machine reaches a conclusion, the calculations conducted, thus the reasons of the conclusion, become too complex for understanding with the limited dimensionality of human perception.[55] The only parts that remain observable are the input, data received from sensors, and the output, action generated as a result of the decision making process.

As stated above, autonomy is the ability of a machine to perform tasks and functions independent of human control. AI, boosted tremendously with machine learning, allows the machines to develop human-like abilities without remaining dependent on humans in the performance of certain tasks and functions. For instance, a self-driving car is able to perceive the lines on the road and shifts the car to the right direction without needing a human operator to use the steering wheel. This is enabled by the advent of AI technologies based on machine learning techniques. Likewise, an autonomous weapon system would be able to detect a target and launch a strike without the need of a human eye to identify the target and a human arm to initiate the launching system.

All in all, autonomy is the end result of AI. Machine learning is now the major technology boosting the development of AI. Hence, it can be said that autonomy is a product of machine learning.[56]

B. Legal Debate on Autonomy: Different Approaches

The technical definition of autonomy clearly conveys an absence of human control for the execution of tasks and functions. However, this definition requires sophistication to correctly reflect the variety of ways autonomy can exist in different systems. Just as active human control might deprive a system of autonomy, absence of human control only in the refuelling capability of a system would also cast a shadow on the system's overall autonomy. Therefore, one of the biggest misconceptions about autonomy is thinking of it through one spectrum.[57] This is a crucial misconception for the legal debate because different applications of autonomy can pose different degrees of challenges in terms of compliance with IHL.

Different solutions to this problem were suggested by scientists. One such example is the Autonomy Levels for Unmanned Systems (ALFUS) approach. It evaluates autonomy as a product of three main factors: the system's human independence, the complexity of the mission assigned to the autonomous functions of the system, and the

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51 Jonathan Kwik and Tom Van Engers, 'Algorithmic Fog of War' (2020) 2(1-2) Journal of Future Robot Life 1, 7.

52 Russell and Norvig (n 43) 693.

53 Will Knight, 'The Dark Secret at the Heart of AI' (*MIT Technology Review*,11 April 2017) <https://www.technologyreview.com/2017/04/11/5113/the-dark-secret-at-the-heart-of-ai/> accessed 23 August 2021.

54 Molnar (n 49) 19.

55 Knight (n 53).

56 Boulanin (n 34) 21.

57 Bradshaw and others (n 13) 2.

difficulty of the environment where the system operates in terms of qualities such as dynamism and risk of adversary. [58]

A popular solution reinforced in legal debates, which has also been often criticized[59] and abandoned by some of its previous supporters[60],is to think of autonomy in levels. Accordingly, the degree of autonomy can be analysed on a spectrum of: human operated systems (Level 1); human delegated systems (Level 2); human supervised systems (Level 3); and fully autonomous systems (Level 4).[61] In human operated systems, the system has no autonomous control of the environment and a human operator makes all the decisions.[62] In human delegated systems, the machine might carry out some functions independently subject to the activation/de-activation of a human operator.[63] Human supervised systems can initiate actions without a specific delegation by the human operator but only within the perimeters of the tasks it has been permitted.[64] Finally, fully autonomous systems are systems that are able to perceive a goal introduced by the human operator, and conducts the necessary steps in order to achieve that goal without the need of any additional human input; although humans can still intervene in times of emergency.[65]

This approach can be problematic primarily because these levels might fail at correctly classifying the existing weapon systems, since not all functions in a weapon system necessarily enjoy the same level of autonomy.[66] In opposition to the levels of autonomy approach, a three-dimensional classification of autonomous systems, seemingly inspired by the ALFUS approach, has been proposed[67] which. It must be noted that some also suggest that this classification is a way of understanding different levels of autonomy,[68] instead of opposing to it. According to this classification, there are three ways to evaluate autonomy: (1) the relationship between the human and the system in terms of command and control; (2) the complexity of the decision-making capabilities of the system; and (3) the types of functions enjoying autonomy.[69]

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58 Hui-Min Huang and others, *Autonomy Levels for Unmanned Systems (ALFUS) Framework, Volume II: Framework Models Version 1.0* (National Institute for Science and Technology 2007) 21; Linell A Letendre, 'Lethal Autonomous Weapon Systems: Translating Geek Speak for Lawyers' (2020) 96 International Law Studies 274, 280-281.

59 Paul Scharre, 'The Opportunity and Challenge of Autonomous Systems' in Andrew P Williams and Paul D Scharre (eds), *Autonomous Systems Issues for Defence Policymakers* (NATO Allied Command Transformation 2015) 3, 9; Bradshaw and others (n 13) 3-4; Chris Jenks, 'False Rubicons, Moral Panic, & Conceptual Cul-De-Sacs: Critiquing & Reframing the Call to Ban Lethal Autonomous Weapons' (2016) 44(1) Pepperdine Law Review 4, 16.

60 Defense Science Board, 'Task Force Report: Role of Autonomy in DOD Systems' (*US Department of Defense* 2012), 23 <https://www.hsdl.org/?view&did=722318> accessed 28 August 2021.

61 Defense Science Board, 'Unmadden Systems Integrated Roadmap FY 2011-2036' (*US Department of Defense*, 2011), 46 https://info.publicintelligence.net/DoD-UAS-2011-2036.pdf accessed 28 August 2021.

62 ibid.

63 ibid.

64 ibid.

65 ibid.

66 Bradshaw and others (n13) 4.

67 Scharre (n 59) 9.

68 Boulanin (n 34) 21.

69 ibid.

i. The human-system interaction

Since autonomy is the ability to perform tasks and functions independent of human control, thinking of autonomy through the interaction between the system and the human operator is a basic and plausible conclusion. This is also the underlying foundation present in the above-mentioned levels of autonomy approach.

According to this dimension, there are three types of interactions that characterize a system's autonomy. Systems that require human input on intervals to perform a task or function are human-in-the-loop or semiautonomous systems as they require humans to continue the tasks they perform on their own. [70] Human-on-the-loop or human-supervised autonomous systems are able to perform tasks and functions on their own however a human operator is able to intervene in case of failures and malfunctions.[71] Human-out-of-the-loop or fully autonomous systems are characterized by a human operator's inability to intervene in the system once the system is activated. [72]

The human-system interaction approach forms a part of the criteria to determine whether an AWS should be banned ,as per Human Rights Watch.[73] In their report, they campaigned for a ban on the development, production, and use of fully autonomous weapons,[74] which was later echoed in the Report of the Special Rapporteur on extrajudicial, summary, or arbitrary executions for characterizing AWS.[75]

The definition given to AWS by certain States also refers to this interaction. France defines AWS as weapons systems with absolute absence of human supervision once activated.[76] Similarly, according to the USA, an AWS is a weapon system that 'once activated, can select and engage targets without further intervention by a human operator'.[77] In the same manner, Japan defines them as weapon systems that 'once activated, can effectively select and engage a target without human intervention'.[78]

The criticisms for the levels of autonomy approach can also be applied to perceiving autonomy as a human-system interaction, since it also oversimplifies different types of systems with different levels of autonomous functions[79] in the same way. Similarly, the human-system interaction does not necessarily remain the same for different tasks on different occasions.[80] For instance, a weapon system that is able to take-off and land autonomously but unable to do so for targeting could be characterized both as human-in-the-loop and human-on or human-out-of-the-loop. Consequently, it can be concluded that

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[70] Scharre (n 59) 10; Myriam Dunn Cavelty and others, '*Killer Robots' and Preventive Arms Control* (Taylor Francis 2016) 468, 458-459.

[71] ibid.

[72] ibid.

[73] Human Rights Watch, 'Losing Humanity: The Case against Killer Robots' (*Human Rights Watch*, 19 November 2012) https://www.hrw.org/report/2012/11/19/losing-humanity/case-against-killer-robots accessed 25 August 2021.

[74] 'The Solution' (*Campaign to Stop Killer Robots*) <https://www.stopkillerrobots.org/learn/#solution> accessed 25 August 2021.

[75] Christof Heyns, 'Report of the Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions, Christof Heyns 23/47' (9 April 2013) UN Doc A/HRC/23/47 para 41.

[76] Government of France, 'Statement to the Convention on Conventional Weapons informal meeting of experts on lethal autonomous weapons systems: 'Vers un définition opérationnelle des SALA'' (13 April 2016) <https://www.reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2016/meeting-experts-laws/statements/12April_France.pdf> accessed 31 October 2021.

[77] 'DoD Directive 3000.09' (US Department of Defense, November 2012) 13.

[78] Government of Japan, 'Statement to the Convention on Conventional Weapons informal meeting of experts on lethal autonomous weapons systems' (9 April 2018) <https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/9April_Japan.pdf> accessed 31 October 2021.

[79] Jenks (n 59) 16.

[80] ibid.

this approach overlooks the distinctions between the characteristics of the functions of the same weapons system and fails to be a generally applicable approach for defining AWS.

ii. The complexity of the decision-making capabilities

It is stated above that there are many techniques to develop narrow AI, i.e., human-like abilities for machines such as machine learning. Autonomy, which is a product of AI, can also be thought through the various steps in the development of AI technology. To describe this, a distinction is made between terms 'automatic', 'automated', and 'autonomous' on the basis of a system's ability to deal with its environment[81] and thus, the complexity of its decision-making algorithms[82] (mentioned above as the control system).

The distinction between each of them is far from clear. 'Automatic' is said to be a simple characteristic of machines that generate mechanical responses to inputs that have been previously introduced to them and only respond to what is foreseen by humans without the capability of dealing with environmental changes. [83] For instance, an anti-vehicle land mine that goes off when the increased pressure on the pressure plate triggers detonation is only capable of responding to pressure and it would not be able to respond to a heat change (unless it affects the pressure) however necessary that might be. Nonetheless, it is also suggested that 'automatic' is execution of a task without human intervention[84] and refers to the same concept of 'autonomy'.[85]

For some scientists, the simplicity of 'automatic' systems is actually 'automation', where humans use machines to perform a specific task.[86] According to them, 'automated' systems can also include more advanced systems where humans retain the ability to control machines through commands from a central computer system[87] without allowing the machine to operate on its own.[88]

In contrast, some engineers[89] and legal scholars observe 'automation' as a characteristic of unsupervised systems capable of independent operation, yet these operations are rather repetitious in nature without requiring the machines to develop complicated responses to the changes in the environment. Accordingly, an anti-vehicle landmine would be an example to an automated system[90] as well as a self-driving car[91] which are only capable of (until now) to make simple manoeuvres possible in each type of road. This limit of only being able to function in environments that are previously introduced to systems is called the ability to function only in *structured* environments. Thus,

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81 Boulanin and Verbruggen (n 10) 8.
82 Scharre (n 59) 10.
83 ibid.
84 Andrew Williams, 'Defining Autonomy in Systems: Challenges and Solutions' in Andrew P Williams and Paul D Scharre (eds) *Autonomous Systems Issues for Defence Policymakers* (NATO Allied Command Transformation 2015) 27, 32)
85 ibid.
86 Matarić (n 18) 2.
87 Stan Gibilisco, *Concise Encyclopedia of Robotics* (McGraw-Hill 2003) 16.
88 ibid 16.
89 Peter Asaro, 'On Banning Autonomous Weapon Systems: Human Rights, Automation, and the Dehumanization of Lethal Decision-Making' (2012) 94(886) International Review of Red Cross 687, 690; Tetyana Krupiy, 'Of Souls, Spirits and Ghosts: Transposing the Application of the Rules of Targeting to Lethal Autonomous Robots' (2015) 16(1) Melbourne Journal of International Law 2, 4.
90 ibid.
91 Scharre (n 59) 10.

they are designed to operate on their own, but they cannot deviate from what they are pre-programmed to do so.[92]

In connection to this line of thinking, 'autonomous' systems can be defined as systems with the ability to generate actions in response in *unstructured* environments that cannot be foreseen from their coding.[93] Hence, 'autonomous' systems are able to perceive themselves, the world, and the changes in the world which they use to attain a specific objective by assessing the different options of action available.[94] A similar but perhaps more demanding definition puts an emphasis on the system's capability of understanding the goal and describes autonomy as the capability to perceive a 'higher-level of intent and direction'.[95]

In the legal debate on the definition of AWS, these distinctions have also been inconsistently adopted in the documents of international organizations such as the UN Report of the Special Rapporteur on extrajudicial, summary or arbitrary executions,[96] as well as by States; usually as a way excluding the pre-existing systems which might qualify as an AWS.[97] For instance, in the 2018 GGE meetings, Italy stated that 'existing automated weapons systems, governed by prescriptive rules and whose functioning is entirely predictable and intended' are excluded from the definition of AWS.[98] Similarly, Sweden stated that in addition to underlying that AWS do not exist today and are a future concern, 'systems such as remotely piloted or automated systems are not within the scope of the GGE'.[99] France also emphasized that the existing automated or teleoperated systems are not included in the scope of discussions on AWS.[100] On the other hand, the United Kingdom specifically defines AWS on the basis of the technical capabilities of the system and positions that an AWS 'is capable of understanding higher-level intent and

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92 Lawrence George Shattuck, 'Transitioning to Autonomy: A human systems integration perspective' (*Presentation at Transitioning to Autonomy: Changes in the role of humans in air transportation*, 11 March 2015),7 <https://human-factors.arc.nasa.gov/workshop/autonomy/download/presentations/Shaddock%20.pdf> accessed 26 August 2021; Defense Science Board, Report of the Defense Science Board Summer Study on Autonomy (*US Department of Defense*, 2016) 4.

93 Scharre (n 59) 10.

94 Shattuck (n 92).

95 Williams (n 84) 33.

96 Heyns (n 75) paras 42-43.

97 Cavelty and others (n 70) 458.

98 Statement of Italy, 'Statement in the Convention on Conventional Weapons informal meeting of experts on lethal autonomous weapons systems: 'Characterization of LAWS'' (9 April 2018) <https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/9April_Italy-characterisation.pdf> accessed 31 October 2021.

99 Statement of Sweden, 'General statement by Sweden at the CCW GGE on Lethal Autonomous Weapons Systems (LAWS)' (9 April 2018) <https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/9April_Sweden.pdf> accessed 30 October 2021.

100 Statement of France, 'Statement in the Convention on Conventional Weapons informal meeting of experts on lethal autonomous weapons system: 'Caractérisation'' (27 August 2018) <https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/27August_France.pdf> accessed 26 August 2021: *'Nos discussions n'ont pas vocation à évoquer les systèmes automatisés ou téléopérés existant actuellement (tels que les drones, les torpilles, les systèmes de défenses automatisés)'.*

direction'.[101] In China, the term AI Weapon is preferred over autonomous weapon, which demonstrates the extent to which complexity of the machine is emphasized.[102]

Although these descriptions draw attention to the variations of the technological background of weapon systems, the distinctions in between are too disputed to be of use. [103] This was also observed by the Chair of the 2014 GGE meeting: 'It became quite obvious that there is no ready-made, generally accepted definition of what is an 'autonomous system' and as to where to draw the line between 'autonomous' and 'automatic' or 'automated'.[104] In the 2018 GGE meeting, the working paper prepared by Estonia and Finland also highlighted that:

The distinction between automated and autonomous functioning is not clear-cut. This is partly because both automated and autonomous systems can have a degree of unpredictability, therefore controlled and stable behaviour of any complex system must be achieved by means of thorough systems design and rigorous testing.[105]

Besides the inconsistency in distinguishing the terms, it is unclear whether they serve any legal use to be a preferable method for the legal definition of AWS. As such, it seems that it would be insignificant to characterize a weapon system as autonomous from the perspective of IHL, as long as it has automated (or automatic) functions in relation to target selection. Ergo, this approach alone does not provide a consistent and a legally direct use for defining AWS.

iii. The functional approach

As stated above, current technology does not seem to pave a speedy way to a General AI but rather towards Narrow AI where certain human-like abilities are developed in machines. Correspondingly, it is considered a misconception to talk about the autonomy of the overall system.[106] Instead, examination should focus on functions enjoying autonomy,[107] so to speak not of autonomous systems but rather autonomy in weapon systems.

International Committee of the Red Cross (ICRC), in an Expert Meeting in March 2014 defined AWS as 'weapons that can independently select and attack targets, i.e., with autonomy in the 'critical functions' of acquiring, tracking, selecting, and attacking targets'[108] and has asserted this definition ever since. The United Nations Institute for

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101 Development, Concepts and Doctrine Centre, '*Joint Doctrine Publication 0-30.2 Unmanned Aircraft Systems'* (UK Ministry of Defence, 2017), 13 <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/673940/doctrine_uk_uas_jdp_0_30_2.pdf> accessed 20 March 2022.

102 Elsa B Kania, *AI Weapons in China's Military Innovation* (Brookings 2020) 2: The Chinese People's Liberation army defined these weapons as *'[…] a weapon that utilizes AI to pursue, distinguish, and destroy enemy targets automatically; often composed of information collection and management systems, knowledge base systems, decision assistance systems, mission implementation systems […]'*.

103 Scharre (n 59) 11; Jenks (n 59) 16.

104 Michael Biontino, 'Summary of Technical Issues at CCW Expert Meeting Lethal Autonomous Weapons Systems (LAWS)' (*German Permanent Missions Geneva*, May 16, 2014) as cited in Jenks (n 59) 13.

105 Governments of Estonia and Finland, 'Categorizing lethal autonomous weapons systems - A technical and legal perspective to understanding LAWS' working paper by Estonia and Finland' (27- 31 August 2018) UN Doc CCW/GGE.2/2018/WP.2.**Error! Hyperlink reference not valid.**

106 Bradshaw and others (n 13) 4-5; Scharre (n 59) 11; Boulanin and Verbruggen (n 10) 11; Jenks (n 59) 24-25.

107 ibid.

108 ICRC, 'Autonomous Weapon Systems: Technical, Military, Legal and Humanitarian Aspects' (*ICRC* 2014), 1 <https://www.icrc.org/en/doc/assets/files/2014/expert-meeting-autonomous-weapons-icrc-report-2014-05-09.pdf> accessed 20 March 2022.

Disarmament Research (UNIDIR), also stressed the need to think about autonomy as a characteristic of functions and not of the system in general.[109]

This 'functional approach' also shaped the statements of many States. Examples include Belgium which stated that AWS discussions should focus on 'systems whose critical functions are autonomous'.[110] Estonia also emphasized that 'autonomy relates to particular functions of the system, rather than the system as a whole'.[111] Norway also defines AWS as systems with autonomy 'at least elements of autonomy, in their 'critical functions'.[112]

The 'functional approach' has found support primarily because of its flexibility to be applicable to the examination of all the weapon systems.[113] However, it was also criticized to be impractical considering the level of significance of human control in these critical functions was unclear.

Further, it is the autonomy in the most legally relevant functions that matters, and the functional approach correctly puts the focus on some functions that are most relevant from an IHL perspective as well as solving the problem of oversimplifying autonomous systems because it breaks them down into functions. For instance, most of the unmanned aerial vehicles (UAV), have autonomous take-off and landing functions but some of them equipped with weapons may as well have autonomous target development functions. Both these different groups of functions may have autonomy, in that, they might operate independently from a human operator. Meanwhile, it would not be plausible to define the former as autonomous because there are so many non-autonomous functions such as navigation destination, refuelling whereas the latter may not be classified as non-autonomous because it enjoys autonomy in certain functions worthy of attention.

It is true that the functional approach does not determine the degree of the absence of human control required in the critical functions.[114] Yet, the abovementioned human-

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[109] UNIDIR, 'Framing Discussions on the Weaponization of Increasingly Autonomous Technologies' (*UNIDIR* 2014), 4 <https://www.unidir.org/files/publications/pdfs/framing-discussions-on-the-weaponization-of-increasingly-autonomous-technologies-en-606.pdf> accessed 20 March 2022.

[110] Statement of Belgium, 'GGE, CCW, Geneva' (9 April 2018) >https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/9April_Belgium.pdf> accessed 20 March 2022 : *'Il est en effet important de mieux définir les contours de notre débat. Celui-ci doit se centrer sur les Systèmes d'armement létaux autonomes, c'est-à-dire des systèmes pour lesquels les fonctions létales critiques sont autonomes. Il est dès lors préférable d'écarter des débats les fonctions autonomes non létales'.*

[111] Statement of Estonia, 'Statement by Estonia in the Group of Governmental Experts on Emerging Technologies in the Area of Lethal Autonomous Weapons Systems: 'Agenda Item 6(a). Characterisation of the systems under consideration'' (27 August 2018) <https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/27August_Estonia.pdf> accessed 31 October 2021.

[112] Statement of Norway, 'Comments made by Norway 28/8/2018 in CCW GGE LAWS Working Sessions 4: Further consideration of the human element in the use of lethal force; aspects of human-machine interaction in the development, deployment and use of emerging technologies in the area of lethal autonomous weapons systems.' (28 August 2018) <https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/28August_Norway.pdf> accessed 31 October 2021.

[113] Scharre (n 59) 11; Boulanin and Verbruggen (n 10) 11; Jenks (n 59) 24-25.

[114] Russian Federation, 'Russia's Approaches to the Elaboration of a Working Definition and Basic Functions of Lethal Autonomous Weapons Systems in the Context of the Purposes and Objectives of the Convention' (4 April 2018) UN Doc CCW/GGE.1/2018/WP.6 **Error! Hyperlink reference not valid.**: ' […]*In ensuring these functions the states should rely on their own standards in this sphere. Attempts to develop certain universal parameters of the so-called 'critical functions' for both existing highly automated war systems and future LAWS – aim identification and hit command, maintaining 'significant' human control – can hardly give practical results. For example, it is doubtful whether criteria to determine a due level of 'significance' of human control over the machine could be developed […]'.*

system interaction approach is only relevant on the point of how an autonomous system is being used and whether this use is legal. As for the decision-making complexity approach, it should only relevant insofar as they respond to the question of whether the task is performed independently of humans, i.e., whether there is autonomy in any function. They should not be relevant in terms of whether the weapon system should be qualified as autonomous. As such, without regard to whether humans can intervene in a system the system should be qualified as 'automatic', 'automated', or 'autonomous', a technical focus must be on whether the function has the ability to perform a task on its own. Thus, the decision-making complexity approach should only complement the functional approach in determining the autonomy in a function. Fortunately, the functional approach is suitable for combination with other approaches.

Nonetheless, what distinguishes one function from another in terms of criticality has been underexamined. This is why in the next chapter, autonomy in 'critical functions' will be elaborately analysed to fully determine the scope of application of IHL in AWS. For this purpose, it will firstly be established that any legal definition of AWS serves the primary purpose of defining the scope of IHL rules, which is why defining 'critical functions' must contain IHL as the main element. Next, the legality of AWS under IHL will be briefly examined to provide the context in which IHL becomes relevant.

III. The pre-eminence of IHL Rules in the legal definition of AWS

The advent of technology is likely to challenge the existing norms of law. The GGE is the international forum for States to regulate AWS[115] to sufficiently address the repercussions of the technology behind AWS on the existing norms that regulate them in international law. The central use of AWS is currently in battlefield and GGE States agree[116] that AWS, as a means of warfare, are regulated by the applicable treaties and norms of customary IHL.[117] Ergo, any international legal definition of AWS must essentially address the needs of the changes brought by the emergence of AWS at the expense of the current norms that regulate weapon systems.

This rationale forms the backbone of many IHL treaties[118] that specifically ban or regulate the use of certain weapons such as the Convention on the prohibition of biological weapons;[119] CCW Protocol III on incendiary weapons;[120] CCW Protocol IV on blinding

[115] CCW (n 1).

[116] Dustin Lewis, 'An Enduring Impasse on Autonomous Weapons' (*Just Security*, 20 September 2020) <https://www.justsecurity.org/72610/an-enduring-impasse-on-autonomous-weapons/> accessed 20 November 2021.

[117] Maslen (n 3) 261; Boothby (n 5) 20-25.

[118] 'Treaties, State Parties and Commentiaries' (International Committee of Red Cross) <https://ihl-databases.icrc.org/applic/ihl/ihl.nsf/vwTreatiesByTopics.xsp> accessed 20 March 2022.

[119] Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (adopted 16 December 1971, entered into force 26 March 1975) 115 UNTS 163.

[120] Protocol on Prohibitions or Restrictions on the Use of Incendiary Weapons (Protocol III) to the Convention on the Prohibition or Restrictions on the Use of Certain Conventional Weapons which may be deemed to be Excessively Injurious or to have Indiscriminate Effects (adopted 10 October 1980, entered into force 2 December 1983) 1342 UNTS 137.

lasers;[121] Convention on Chemical Weapons;[122] Revised CCW Protocol II on mines, booby traps and other devices;[123] Anti-Personnel Mine Ban Convention[124] and the Convention on Cluster Munitions.[125] These treaties define the weapons or weapon systems they regulate in a sufficient manner to properly determine their scope of application. Some of them are confined to a general definition, such as but not limited to[126] Article 1 of the Biological Weapons Convention, which defines biological weapons as 'microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes'. A similar but more detailed approach is to provide sub-definitions that complete the general definition as well as provide an annex that mentions these weapons. For instance, Article 2 of the Convention on Chemical Weapons defines chemical weapons as 'toxic chemicals and their precursors' as well as 'munitions and devices' designed to cause harm through them. Subsequently, toxic chemicals are defined as 'any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals', and 'precursor' as 'any chemical reactant which takes part at any stage in the production by whatever method of a toxic chemical' in addition to referring to annex that enumerates these definitions. Another way is an exclusionary definition. Article 2 of the Convention on Cluster Munitions offers a long list of what is not a cluster munition[127] after defining them as 'means a conventional munition that is designed to disperse or release explosive submunitions each weighing less than 20 kilograms and includes those explosive submunitions'.

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[121] Protocol on Blinding Laser Weapons (Protocol IV) to the Convention on the Prohibition or Restrictions on the Use of Certain Conventional Weapons which may be deemed to be Excessively Injurious or to have Indiscriminate Effects (adopted 13 October 1995, entered into force 30 July 1998) 1342 UNTS 137.

[122] Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (adopted 13 January 1993, entered into force 29 April 1997) 1974 UNTS 45.

[123] Protocol on Prohibitions or Restrictions on the Use of Mines, Booby-Traps and Other Devices as amended on 3 May 1996 (Protocol II) to the to the Convention on the Prohibition or Restrictions on the Use of Certain Conventional Weapons which may be deemed to be Excessively Injurious or to have Indiscriminate Effects as amended on 3 May 1996 (adopted 3 May 1996, entered into force 3 December 1998) 2048 UNTS 93.

[124] Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction (adopted 18 September 1997, entered into force 1 March 1999) 2056 UNTS 211.

[125] Convention on Cluster Munitions (adopted 30 May 2008, entered into force 1 August 2010) 2688 UNTS 39.

[126] CCW Protocol IV (n 121), Art 1 on blinding lasers: 'It is prohibited to employ laser weapons specifically designed, as their sole combat function or as one of their combat functions, to cause permanent blindness to unenhanced vision, that is to the naked eye or to the eye with corrective eyesight devices […]'; CCW Protocol III (n 120), Art 1 on incendiary weapons: ' 'Incendiary weapon' means any weapon or munition which is primarily designed to set fire to objects or to cause burn injury to persons through the action of flame, heat, or combination thereof, produced by a chemical reaction of a substance delivered on the target.'

[127] Convention on Cluster Munitions (n 125), Art 2(2): 2. 'Cluster munition' means a conventional munition that is designed to disperse or release explosive submunitions each weighing less than 20 kilograms, and includes those explosive submunitions. It does not mean the following:(a) A munition or submunition designed to dispense flares, smoke, pyrotechnics or chaff; or a munition designed exclusively for an air defence role;(b) A munition or submunition designed to produce electrical or electronic effects;(c) A munition that, in order to avoid indiscriminate area effects and the risks posed by unexploded submunitions, has all of the following characteristics:
(i) Each munition contains fewer than ten explosive submunitions;
(ii) Each explosive submunition weighs more than four kilograms;
(iii) Each explosive submunition is designed to detect and engage a single target object;
(iv) Each explosive submunition is equipped with an electronic self-destruction mechanism;
(v) Each explosive submunition is equipped with an electronic self-deactivating feature.

There is no such treaty specific to AWS but the approach in weapon-specific treaties should shed some light on the debate on the definition of AWS. The common point in each of these weapon-specific treaties is to define the distinguishing characteristics of weapons or weapon systems. These are not irrelevant technical characteristics but rather characteristics that make the nature or use of these weapons substantially likely to trigger incompliance with IHL because after all, this is the reason that these definitions are stipulated in an IHL treaty.

It is thus inevitable that critical functions in the definition of AWS should include IHL as the pre-eminent element. In the next chapter, the interaction between AWS and IHL will be briefly examined.

IV. AWS under IHL and Critical Functions of a Weapon System

It must be born in mind that an essential part of the 'functional approach' to the definition of AWS should be the focus on critical functions of weapon systems, as suggested by ICRC. In the 2018 GGE meeting, Poland conveniently put an emphasis on the ultimate goal of the debate on the definition of AWS by asking:

Do we want to define AWS in order to ban them? Or do we want to create a broad definition of fully autonomous weapons systems and then determine to what extent a human control over specific functions of these systems is required?[128]

Putting aside the potential answers to this question, this question brings attention to the fact that the overall challenge of the legal discussion on the definition of AWS is to assess their legality under IHL better. The *raison d'être* of any legal definition is to define the scope of application of the law. Particularly for IHL, definitions take the most painstaking part. For instance, drawing the line between the definitions of a civilian and a civilian directly participating in hostilities is the heart of the ground of protection provided by IHL.[129] Similarly, if one falls into the definition of a combatant, they acquire rights and responsibilities that has significant repercussions.[130] In the same manner, if a weapon system is an AWS, as the current debates show, IHL will either require additional norms of IHL, such as the obligation to ensure meaningful human control,[131] or require different applications of them. Seemingly to this vein, Switzerland defines AWS as 'weapons systems that are capable of carrying out tasks governed by IHL in partial or full replacement of a human in the use of force, notably in the targeting cycle'.[132]

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128 Government of Poland, 'Working Paper on Lethal Autonomous Weapons Systems submitted by Poland' (28 March 2018) <https://docs-library.unoda.org/Convention_on_Certain_Conventional_Weapons_-_Group_of_Governmental_Experts_(2018)/CCW_GGE.1_2018_WP.3.pdf> accessed 31 October 2021.

129 Additional Protocol I to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (adopted 8 June 1977, entered into force 7 December 1978) 1125 UNTS 3 [AP1], Art 43(2).

130 ibid Art 51(3) of AP1.

131 Netta Goussac, 'Safety Net or Tangled Web: Legal Reviews of AI in Weapons and War-Fighting' Humanitarian Law & Policy (*ICRC,* 18 April 2019) <https://blogs.icrc.org/law-and-policy/2019/04/18/safety-net-tangled-web-legal-reviews-ai-weapons-war-fighting/> accessed 31 October 2021.

132 Statement of Switzerland, 'Statement in Group of Governmental Experts on lethal autonomous weapons systems (LAWS) 2018, Convention on Certain Conventional Weapons: 'Agenda item 6 a) Characterization of the systems under consideration in order to promote a common understanding on concepts and characteristics relevant to the objectives and purposes of the Convention'' (10 April 2018) <https://docs-library.unoda.org/Convention_on_Certain_Conventional_Weapons_-_Group_of_Governmental_Experts_(2018)/2018_LAWS6a_Switzerland.pdf> accessed 31 October 2021.

Another utility of the 'functional approach' is to explore the weapon systems through a lens that demonstrates their importance for the application of IHL. After all, it is insignificant to IHL that a trifle is dark grey or black, but crucial when its bullets are more than 1 calibre as this might cause unnecessary suffering.[133] Therefore, a meticulous examination of autonomy in 'critical functions' will determine the scope of application of IHL in AWS.

This section of the article will first examine the rules regulating the weapon systems under IHL. It will then explain how AWS might raise concerns under IHL. Subsequently, it will expand on the functions of weapon systems and suggest a list of categorizing and characterizing them. Finally, it will draw up a conclusion on which of these functions must be deemed critical based on these explanations.

A. Weapon systems under IHL

There is considerably little debate on the applicability of IHL to weapon systems.[134] Weapons, as a means of warfare, are regulated by the applicable treaties and norms of customary IHL.[135] In this regard, Additional Protocol 1 to the 1949 Geneva Conventions (AP1) is a prominent source, most of the relevant parts of which is accepted to reflect the norms of customary IHL.[136] According to Article 35(1) of AP1, parties to an armed conflict are not unlimited in their choice of methods or means of warfare.[137]

A distinction must be made between the rules applicable to the inherent nature of weapons due to their design, and the use of weapons.[138] Weapons that cause unnecessary harm by their nature[139] and weapons 'that are incapable of distinguishing between civilian and military targets'[140] are illegal under IHL due to their design. The use of weapons, on the other hand, must be in compliance with the principle of distinction (the obligation to distinguish between lawful and unlawful targets),[141] the principle of precaution (the obligation to take all reasonable measures to minimize civilian harm),[142] and the principle of proportionality (the obligation to strike a balance between the collateral damage and military advantage).[143] In addition to these general rules, the above-mentioned treaties bear obligations to restrict or ban certain weapons among States that are party to these treaties.

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[133] AP1 (n 129) Art 35(2).

[134] Dustin Lewis, 'An Enduring Impasse on Autonomous Weapons' (*Just Security*, 20 September 2020) <https://www.justsecurity.org/72610/an-enduring-impasse-on-autonomous-weapons/> accessed 20 November 2021; See also on the fact that IHL applicability on AWS is undisputed in Neil Davidson, 'A Legal Perspective: Autonomous Weapon Systems under International Humanitarian Law' [2016] UNODA Occasional Papers No. 30 5, 7.

[135] Maslen (n 3) 261.

[136] Boothby (n 5) 17; Michael N Schmitt, 'War, Technology and the Law of Armed Conflict' (2006) 82 International Law Studies - The Law of War in the 21st Century: Weaponry and the Use of Force 137, 139.

[137] AP1 (n 129) Art 35(1).

[138] Maslen (n 3) 263; Robin M Coupland, The SIrUS Project Towards a determination of which weapons cause 'superfluous injury or unnecessary suffering (*International Committee of Red Cross* 1997) 10-1.

[139] AP1 (n 129) Art 35(2); Boothby (n 5) 60; Coupland (n 138) 10-11; Kwik and Van Engers (n 51) 10.

[140] AP1 (n 129) Art 51(4)(b)-(c); *Legality of the Threat of Use of Nuclear Weapons* (Advisory Opinion) [1996] ICJ Rep 66 [78]; Boothby (n 5) 60; Kwik and Van Engers (n 51) 10.

[141] AP1 (n 129) Art 51(4)(a).

[142] AP1 (n 129) Art 57(2)(a)(iii); *The Prosecutor v Zoran Kupreskic, Mirjan Kupreskic, Vlatko Kupreskic, Drago Josipovic, Dragan Papic, Vladimir Santic* (Judgment) (2000) ICTY-95-16 [533]; Boothby (n 5) 37; Krupiy (n 89) 16.

[143] AP1 (n 129) Art 57(2); Boothby (n 5) 37.

B. AWS under IHL

Like the other weapon systems, AWS' compliance with IHL raises questions stemming from the nature of the system or its use. Regarding its nature, problems are more likely to arise on the capability of AWS to distinguish between lawful and unlawful targets (the indiscriminate weapons rule) than the prohibition of superfluous injury and unnecessary suffering. Considering that AWS are weapon platforms on which a variety of weapons might be installed, AWS might as well violate the prohibition on superfluous injury and unnecessary suffering. Yet this is not a result of the peculiarity of AWS, which is autonomy through AI and machine learning, but rather the choice of weaponry installed on it.[144]

On the other hand, indiscriminate weapons rule stipulates that it is prohibited to use weapons which 'cannot be directed at a specific military objective' or 'the effects of which cannot be limited' and thus, cannot by their nature distinguish between lawful and unlawful targets under IHL.[145] Concerns raised for AWS in this regard can be explained in two parts. To begin with, it is unsettled whether AWS will be able to make the distinctions required by IHL.[146] Further, in the likely possibility that they can, the randomized algorithms and 'black box' operations as a result of machine learning techniques in the decision-making process of the systems will create significant predictability problems in guaranteeing this result. [147] Human operators will not be able to foresee a failure likely to be caused by a system able to operate on its own for the simple fact that their transparent observation is limited to the input into the system, but decision-making process is too complicated for them to humanly untangle.[148] This is especially the case when the training of weapon systems unable to take place in the real world due to ethical reasons will complicate the functioning of the system in the existence of rich data from the real world.[149] Consequently, the output might also be clouded. In fact, perhaps for systems where pre-programming is dominant and the machine learning applications are limited, this is not a serious issue. Nevertheless, as explained above, machine learning is an advantageous option that more and more replaces hand-coded programming. Ergo, the likelihood of predictability issues is not ignorable.

As stated, an AWS which might perhaps not be indiscriminate by design must also comply with the with the principle of distinction under IHL when it is in use. But at that point, parallel to the prohibition on superfluous injury and unnecessary suffering, this will no longer be a problem peculiar to the autonomy of weapon systems.

More critically, AWS must comply with the principle of proportionality, which obliges quantitative and qualitative analyses conducted to ensure that the civilian harm to be inflicted in the process of achieving a military advantage is not excessive.[150] A quantitative analysis is likely to be accurately made by the AWS[151] whereas the balance between collateral damage and military advantage is thought to be difficult to translate into codes for the AWS to assess through permutations[152] and without sacrificing predictability

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[144] Kwik and Van Engers (n 51) 10.

[145] AP1 (n 129) Art 51(4)(b)-(c); Boothby (n 5) 17, 66, 67.

[146] Amanda Sharkey, 'Autonomous Weapons Systems, Killer Robots and Human Dignity' (2019) 21 Ethics and Information Technology 75, 76; Noel E Sharkey, 'The Evitability of Autonomous Robot Warfare' (2012) 94(886) International Review of the Red Cross 787, 788; Kwik and Van Engers (n 51) 11.

[147] Kwik and Engers (n 51) 12.

[148] ibid.

[149] ibid.

[150] Kwik and Engers (n 51) 13; Sharkey (n 146) 788.

[151] Ronald C Arkin, *Governing Lethal Behavior in Autonomous Systems* (Taylor Francis 2009) 47–48.

[152] Krupiy (n 89) 17.

in the use of machine learning.[153] Similarly, the principle of precaution, which requires all feasible measures to be taken to minimize collateral damage, might also incur problems[154] particularly for it will require subjective evaluations of what qualifies as feasible.[155]

As can be seen from this brief legality assessment, IHL focuses on the interaction between the weapon systems and the targets, and it is this interaction that creates the context of questions arising from compliance with IHL. For AWS, autonomy in critical functions is what creates this context and triggers a substantial likelihood of incompliance with IHL. As such, autonomy in some functions (e.g., refuelling functions) raise lesser concerns under IHL than others (e.g., attack functions).[156] The likelihood of a particular function must be 'substantial' to form a context in IHL considerations may rise. This is why an emphasis on autonomy in critical functions should be an integral part to the definition of AWS.

C. Functions of a weapon system and critical functions

ICRC always mentioned these critical functions in a consistent manner as 'critical functions of acquiring, tracking, selecting and attacking targets'.[157] What these functions cover exactly and whether other functions should be included are worthy of attention to correctly elaborate on this notion so much so that calls have been made to refocus the debate in CCW meetings on critical functions instead of futilely trying to define what would make a system 'fully' autonomous.[158] There are three reasons why this paper will attempt to provide a detailed analysis of the critical functions.

First, unlike the definition of AWS in general, the content of the concept of critical functions has not been challenged in detail. Although ICRC broadly categorizes them as target selection and attack, it does not correctly capture the technical nuances that might lead to an IHL violation. For instance, as will be further elaborated below, many studies point to the fact that the advance of weapon technologies is likely to lead to autonomy in an increasing number of functions.[159] functions related to provision of information (i.e., intelligence functions) may also be critical with the advance of technology provided that they influence targeting. Thus, more discussion on whether critical functions are limited to a specific section of the targeting process i.e., acquiring, tracking, selecting, and attacking targets or they can be expanded will be fruitful.

Second, it can be said that there is an increasing acceptance of the concept, and it is becoming more prevalent in the definitions of States.[160] Defining its content is crucial to render this acceptance meaningful and prevent possible circumventions of the notion by stretching it in the absence of any.

Last but not least, the concept of critical functions started to be the backbone of the discussions on meaningful human control (MHC). It is a requirement that a meaningful

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153 Sharkey (n 146) 788; Kwik and Van Engers (n 51) 13.

154 Maya Brehm, 'Defending the Boundaries: Constraints and Requirements on the Use of Autonomous Weapon Systems Under International Humanitarian and Human Rights Law' [2017] Geneva Academy Briefing No 9 51-52; Krupiy (n 89) 17.

155 Kwik and Van Engers (n 51) 13.

156 Jenks (n 659) 25: See Figures 2 and 3.

157 ICRC, Report of the ICRC Expert Meeting on 'Autonomous weapon systems technical, military, legal and humanitarian aspects' (*ICRC* 2014) 62.

158 Chris Jenks, 'The Distraction of Full Autonomy and the Need to Refocus the CCW Laws Discussion on Critical Functions' in Robin Geiss (ed), Lethal Autonomous Weapons Systems: Technology, Definition, Ethics, Law & Security (Federal Foreign Office 2017) 171, 183.

159 Boulanin and Verbruggen (n 10) 27, 29, 33.

160 ibid 6.

human control must be exerted on AWS[161] and there is almost a consensus that there should be some form of MHC, although there are serious debates on its content. These debates depend on the dichotomy of thought of the normative nature of this requirement. On the one hand, it is asserted that MHC is an independent underlying requirement of IHL. [162] Accordingly, even with all problems pertaining to the capacity and predictability of AWS, MHC will still be needed for the reason that the rules of IHL are addressed to humans[163] and 'it is humans that comply with and implement the law'.[164] On the other hand, it is claimed that MHC is a principle for ensuring compliance with IHL[165] and if AWS will ever be better in terms of compliance with IHL, there will be no need for such principle.[166] Some even go so far as to suggest that then it might be an obligation for States to use AWS.[167] In any event, discussions on MHC are heavily reliant on where the criticality lies in the functions of weapon systems. Many States suggest that the meaningful human control should be on the AWS' critical functions.[168] Another approach has also been defining MHC in a flexible way to allow for determination of functions that are critical for each weapon system, considering their peculiarities.[169] In any case, the

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[161] UK Government'Killer Robots: UK Government Policy on Fully Autonomous Weapons' (*Article 36*, April 2013) <https://article36.org/wp-content/uploads/2013/04/Policy_Paper1.pdf> accessed 28 August 2021.

[162] Nette Goussac (n 131).

[163] Eric Talbot Jensen, 'The (Erroneous) Requirement for Human Judgment (and Error) in the Law of Armed Conflict' (2021) 96 International Law Studies 26, 55.

[164] ICRC, *Artificial Intelligence and Machine Learning in Armed Conflict: A Human-Centred Approach* (ICRC 2019) 7, 8.

[165] Tim McFarland, 'Autonomous Weapons and Human Control' (*ICRC,* 18 July 2018)<https://blogs.icrc.org/law-and-policy/2018/07/18/autonomous-weapons-and-human-control/>accessed 31 October 2021: *'[…]exercising meaningful human control means employing whatever measures are necessary, whether human or technical, to ensure that an operation involving an AWS is completed in accordance with a commander's intent and with all applicable legal, ethical and other constraints'.*

[166] Jensen (n 163) 55.

[167] ibid 56.

[168] Statement of Austria, 'Statement in Group of Governmental Experts on Lethal Autonomous Weapon Systems: 'General Exchange of views'' (9 April 2018) <*https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/9April_Austria.pdf*> accessed 31 October 2021: MHC focus should be on *'[…] level of autonomy or human involvement in critical functions […]'*; Statement of Germany, 'Intervention of the Germany on Agenda Item: 'Further Consideration of the Human Element in the use of Lethal Force' (28 August 2018) <https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/28August_Germany.pdf> accessed 31 October 2021: solution to the accountability problemrelies on the fact that '*[…] humans retain sufficient control over the critical functions […]*'; Statement of Poland, 'Statement of the Delegation of Poland in 2nd GGE on LAWS' (11 April 2018) <https://reachingcriticalwill.org/images/documents/Disarmament-fora/ccw/2018/gge/statements/11April_Poland.pdf> accessed 31 October 2021: *'[…]human control over the critical functions of weapon systems need to be retained […]*'.

[169] Statement of United States, 'U.S. Delegation Statement on Human-Machine Interaction at the Meeting of the Group of Governmental Experts of the High Contracting Parties to the CCW on Lethal Autonomous Weapons Systems' (28 August 2018) <https://geneva.usmission.gov/2018/08/28/u-s-delegation-statement-on-human-machine-interaction/> accessed 31 October 2021: *' […]Because advances in autonomous technologies could support both military and humanitarian interests, the United States believes that we need to be very careful in addressing issues of emerging technologies. We must not stigmatize new technologies nor seek to set new international standards. Instead, States should ensure the responsible use of emerging technologies in military operations by implementing holistic, proactive review processes that are guided by the fundamental principles of the law of war […]'.*

understanding of MHC has a great impact on the realization of advantages[170] and disadvantages of AWS in the battlefield. Therefore, it can be concluded that a comprehensive analysis on the concept of critical functions will also be crucially beneficial for the debate on MHC.

To properly analyse the concept of critical functions, two sets of questions must be raised. What are the functions of a weapon system? Which of them are critical and why? First and foremost, it must be clarified that this chapter will not portray a complete picture of all the technical functions of a weapon system since this would vary from one weapon to another and not be of great use. Instead, common functions of weapon systems will be scrutinized.

As explained above, functions of a weapon system are 'AIised' and develop autonomy as a result. Stockholm International Peace Institute (SIPRI) developed a dataset through a study of 381 weapon systems with some autonomy in some of their functions[171] and grouped these functions as: (1) 'Mobility' functions; (2) Functions related to 'health management'; (3) 'Targeting' functions'; (4) 'Intelligence' functions; and (5) 'Interoperability' functions'.[172] These groups are sufficiently inclusive of contemplating on the functions of a weapon system and their criticality as they are not constrained to functions of targeting and attacking. For this reason, this chapter will be based on the groupings of functions in the SIPRI report prepared by Vincent Boulanin and Maaike Verbruggen.

i. 'Mobility' functions

Main mobility functions include homing and follow-me functions; navigation and functions related to take off-and landing.[173] Homing is the function of following a specified target and follow me is following another system or soldier.[174] Navigation is system's function to position itself and plan/follow a route. [175] Take-off and landing are the aircraft's operation of leaving the ground and returning to it.

Autonomy in these functions exists to various extents.[176] Nevertheless, despite forming a critical part of an AWS' operation, autonomy in these functions cannot be deemed critical. They may be important in terms of the functionality of the AWS, but if there were to be an IHL violation for the reasons explained above, it would not be because mobility functions enjoy autonomy. Ergo, they do not raise the substantial likelihood of incompliance with IHL They cannot play a part in the interaction between the weapon system and the targets, nor this interaction is dependent on it. They only precede this interaction and failure in mobility functions is the failure of the use of the system as a whole.

ii. Functions related to 'health management'

Functions performed for health management can be grouped mainly as functions of 'health-monitoring'[177] of the system's own health, 'self-recharging/-refuelling' of the system once it runs out of the required operational energy,[178] 'fault detection and

[170] Rebecca Crooftop, 'A Meaningful Floor for 'Meaningful Human Control' (2015) 30 Temple International & Comparative Law Journal 53, 62.
[171] Boulanin and Verbruggen (n 10) 19.
[172] ibid 21.
[173] Boulanin and Verbruggen (n 10) 23.
[174] ibid.
[175] ibid.
[176] ibid.
[177] ibid.
[178] ibid 35.

diagnosis',[179] and 'self-repair'.[180] Much as it can be stated that these functions are critical for the overall functioning of the system, they are not as critical in the interaction between the weapon system and the targets considering they are independent of whether or not that interaction takes place.

iii. 'Targeting' functions

Targeting is, first and foremost, a military term the content of which has been intricately described and regulated by military standards. In IHL terms, it can be thought of as 'attack'.[181] However, it would be misleading since targeting is more of a process than a single step. It can be roughly defined as the deliberate application of 'means (weapons) of warfare to affect addressees (people or objects) using a variety of methods (tactics) that create effects contributing to designated goals'.[182] It acts as a 'bridge between the ends and means of warfare'.[183] From this perspective, it truly seems to be the interaction itself between the weapon system and the targets, let alone playing a part of it, which is why there seems to be much less discussion on the critical nature of targeting functions although the debate on the legality of autonomy in these functions is still ongoing.

iv. 'Intelligence' functions

One part of 'intelligence' functions is related to system's ability to collect and process data and it is comprised of functions related to the system's ability to handle information.[184] This includes, but not limited to, 'detection of explosive devices' for destruction purposes, [185] detection of intrusion by unauthorized living beings into a predefined area,[186] detection and location of the gunfire or other weapon fire in terms of direction and range,[187] as well as 'detection of objects of interest' in intelligence, surveillance and reconnaissance (ISR) missions.[188]

Another part of 'intelligence' functions is related to system's ability to generate data.[189] Examples include 'map generation' where the systems map the environment with certain details,[190] 'threat assessment' where the systems asses the risk potential of certain objects based on predefined criteria[191], and use of 'big data analytics' to find correlations and recognize patterns.[192]

To the extent that these functions form an integral part of the interaction between the weapon system and the targets, they will be critical, and assessment must be made for each function *in casu.* For instance, the detection of explosive devices forms an important part of the use of the weapon system to destroy explosives such as landmines, sea mines or

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179 ibid.

180 ibid.

181 Michael N Schmitt and Eric Widmar ,'The Law of Targeting' in Paul AL. Ducheine, Michael N Schmitt and Frans PB Osinga (eds) *Targeting: The Challenges of Modern Warfare* (Springer 2016) 121, 123.

182 Paul AL Ducheine, Michael N Schmitt and Frans PB. Osinga, 'Introduction' in Paul AL Ducheine, Michael N Schmitt and Frans PB. Osinga (eds) *Targeting: The Challenges of Modern Warfare* (Springer 2016) 2.

183 ibid.

184 Boulanin and Verbruggen (n 10) 27.

185 ibid.

186 ibid 28.

187 ibid.

188 ibid.

189 ibid 29.

190 ibid.

191 ibid.

192 ibid.

improvised explosive devices,[193] in the sense that engagement with the target depends on the information gathered by the system. Similarly, information in threat assessment, can sometimes form the bulk of target development.[194] Therefore, functions related to intelligence must be handled with care when determining their criticality as they might form an integral part to the engagement with targets.

v. 'Interoperability' functions

Interoperability is the ability of the system 'to operate in conjunction'[195] with other systems[196] or humans.[197]

Interoperability between systems may vary from rather primitive forms of exchange of data to 'collaborative autonomy' where systems work in coordination to achieve one common goal.[198] The latter may be collaboration for coordination in mobility[199] and in ISR operations,[200] for surveillance and protection of a predefined area[201] and carrying out 'distributed attacks'.[202] It must be noted that collaborative autonomy in these functions are more in the research phase.[203]

Interoperability between systems is likely to be critical in the interaction between the weapon system and the targets in the perimeters for which independent function the cooperation will occur. For instance, carrying out distributed attacks is definitely a critical function in the interaction between the weapon system and the targets, but this is due to the functions related to attack not interoperability. From this perspective, interoperability functions do not seem to have critical value independent from other functions in a weapon system. However, with the increasing use of randomized algorithms and the advent of machine learning, systems' cooperation to achieve a common goal may involve decision-making processes that humans are either incapable of understanding or worse; of intervening. After all, randomized algorithms and machine learning are ways to make systems solve problems and solutions may sometimes exclude humans. Therefore, although it is premature to suggest that interoperability functions are critical at this stage, future versions might have consequences on decision-making processes that will naturally have an impact on the interaction between the weapon system and the targets, thus, play a critical role.

As to interoperability between systems and humans, despite lacking real-world applications due to a primary problem of human-machine communication, it can be thought as a model where humans cooperate with the systems as if they sense the world with human-like abilities such as speech recognition and demand for assistance over actions.[204] This would also depend on the functions assumed by the system and the sophistication of the decision-making capability of the system to affect the role of humans in the cooperation.

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193 ibid.
194 ibid.
195 ibid.
196 ibid 30.
197 ibid 33.
198 ibid 30.
199 ibid.
200 ibid.
201 ibid.
202 Boulanin and Verbruggen (n 10) 31.
203 ibid 30.
204 ibid 34.

D. A brief case study of critical functions: Turkish Autonomous Weapon Systems in Libya 'STM-KARGU'

One of the most novel examples in the discussion of AWS is brought about by the recent impetus in the 'dronization' of the Turkish National Defence Industry. that led to the emergence of the loitering munition system STM-KARGU,[205] by STM (*Savunma Teknolojileri Ticaret AŞ*), a state-owned company.

KARGU has been used actively in Libya in Turkish support for the Libyan Government of National Support against Hafter, and it has recently been cited by the panel of experts in their report to the United Nations Security Council as the first Lethal Autonomous Weapon System having launched a fully autonomous attack in Libya.[206] It is worth analysing whether this report was an early bird.

In the following two sections, STM-Kargu will be briefly introduced, and then functions of it will be scrutinized according to the SIPRI groupings of functions of weapon systems with somewhat autonomy which were: 1) 'Mobility' functions ; (2) Functions related to 'health management' ; (3) 'Targeting' functions' ; (4) 'Intelligence' functions; and (5) 'Interoperability' functions'.[207] Finally, the autonomy in its critical functions will be evaluated.

i. Overview of STM-Kargu

Kargu, which means 'watchtower' in ancient Turkish, is defined by STM as a 'Rotary Wing Attack Drone Loitering Munition System'.[208] It became operational in 2020 after its introduction to the Turkish Armed Forces.[209] Later, it was deployed and used in Libya in the spring of 2020[210] and disputably in Nagorno-Karabagh in October 2020.[211] Though little is known about their use in Nagorno-Karabagh, in Libya, they became notorious for having performed an autonomous target engagement. [212]

Loitering munitions are unmanned aerial vehicles equipped with an explosive warhead.[213] They are also known as suicide drones since the majority of them are not recoverable after they detonate. [214] They *loiter* for an extended period in a conflict zone to find and strike the target based on the ground[215] through high-resolution cameras,[216] then they hit their target with the sort of explosive with which they are equipped.

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205 STM, 'Kargu: Rotary Wing Attack UAV' (*STM*) <https://www.stm.com.tr/en/KARGU-autonomous-tactical-multi-rotor-attack-uav> accessed 28 October 2021.

206 UNSC 2021 (n 2) para 63.

207 Boulanin and Verbruggen (n 10) 21.

208 STM,'Tactical Mini UAV Systems' (*STM*) 2 <https://www.stm.com.tr/uploads/docs/1628858259_tacticalminiuavsystems.pdf> accessed 29 October 2021.

209 Emre Eser, 'İlk Drone Gücü' (*Hürriyet,* 12 September 2019) <https://www.hurriyet.com.tr/ekonomi/ilk-drone-gucu-2020de-41328505> accessed 29 October 2021.

210 UNSC 2021 (n 2) para 63.

211 'İlk kez Libya'da kullanılmıştı! Bu kez Azerbaycan'da görüntülendi' (*CNN Türk,* 28 October 2020) <https://www.cnnturk.com/dunya/ilk-kez-libyada-kullanilmisti-bu-kez-azerbaycanda-goruntulendi> accessed 29 October 2021.

212 UNSC 2021 (n 2) para 63.

213 Dan Gettinger andArthur H Michel, 'Loitering Munitions in Focus' (*Center for the Study of Drones* 2017), 1 https://dronecenter.bard.edu/loitering-munitions-in-focus/ accessed 20 March 2022.

214 ibid.

215 Andrea Gilli andMauro Gilli, 'The Diffusion of Drone Warfare? Industrial, Organizational, and Infrastructural Constraints' (2016) 25(1) Security Studies 50, 67.

216 Gettinger and Michel (n 213).

ii. Technical aspects of STM-Kargu and autonomy in its functions

To begin with the technical features of STM-Kargu, it consists of an 'Attack Drone Platform' and the 'Mobile Ground Control Station'.[217] It may be equipped with multiple warheads (such as anti-personnel or armour piercing)[218] limited to a payload of up to 1,3 kg.[219] It can loiter for 30 minutes before aborting the mission and returning home;[220] thus, it is recoverable. At the Mobile Ground Control Station, it is operable by single personnel.[221] Capable of detecting and recognizing targets in and beyond sight through its electro-optical and infrared cameras, STM-Kargu allows the personnel to conduct reconnaissance, surveillance, intelligence missions, and carry out precision strikes by day and night.[222]

STM-Kargu's mobility functions are stated to be fully autonomous.[223] No data of critical importance may be discussed concerning its health management functions. STM-Kargu uses its electro-optical and infrared cameras to gather information. Still, there is no available data to assume autonomy in intelligence functions since nothing suggests that it processes or generates data based on this piece of information.

STM-Kargu has interoperability functions as indicated by its reported full swarming capabilities[224] and operation in a swarm of 30 drones.[225] However, in addition to the current stage of technology in general and lack of evidence on autonomous machine-machine interaction of STM-Kargu in particular, the small number of drones and the short loitering time denotes the unlikelihood of autonomy in STM-Kargu's interoperability functions.

The more attention-grabbing part is STM-Kargu's targeting functions. STM-Kargu can be operated by single personnel, but STM designed STM-Kargu with an Automatic Target Recognition System[226] and states that it has automatic target detection and tracking capabilities in its video advertisement.[227] Ergo, 'target recognition' may be carried out autonomously. However, it is stated in exact words on the company's website that 'Precision strike mission is fully performed by the operator, in line with the Man-in-the-Loop principle'.[228] The CEO of STM indicated that STM-Kargu could only strike once the operator confirms and commands it, and the operator is able to abort the mission at any

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[217] STM (n 208).

[218] STM, 'KARGU – Rotary Wing Attack Drone Loitering Munition System' (*STM*) <https://www.youtube.com/watch?v=auRlh-f2wwQ> accessed 29 October 2021.

[219] STM (n 208) 3.

[220] ibid.

[221] STM, 'KARGU - Taşınabilir Döner Kanatlı Vurucu İHA Sistemi' (*STM*) <https://www.stm.com.tr/tr/cozumlerimiz/otonom-sistemler/KARGU> accessed 29 October 2021.

[222] ibid.

[223] STM (n 208).

[224] STM, 'KARGU - Autonomous Tactical Multi-Rotor Attack UAV' (*STM*, 2018) <https://www.youtube.com/watch?v=Oqv9yaPLhEk&t=1s>accessed 29 October 2021; Goksel Yildirim, 'Anadolu Agency tours state-of-the-art Turkish UAV maker' (*Anadolu Agency*, 15 June 2020) <https://www.aa.com.tr/en/economy/anadolu-agency-tours-state-of-the-art-turkish-uav-maker/1877808> accessed 29 October 2021; Diane Francis, 'Turkey's Terminator' (*The Mackenzie Institute*, 25 June 2021) https://mackenzieinstitute.com/2021/06/turkeys-terminator/accessed 29 October 2021; David Hambling, 'Turkish Military To Receive 500 Swarming Kamikaze Drones' (*Forbes*, 17 June 2020) <https://www.forbes.com/sites/davidhambling/2020/06/17/turkish-military-to-receive-500-swarming-kamikaze-drones/?sh=488c8fda251a> accessed 29 October 2021.

[225] Frank Slipjer, 'Slippery Slope: The Arms Industry And Increasingly Autonomous Weapons' (*Pax for Peace* 2019), 9 https://paxforpeace.nl/media/download/pax-report-slippery-slope.pdf accessed 20 March 2022; Emre Eser, 'İlk Drone Gücü' (*Hürriyet*, 12 September 2019) <https://www.hurriyet.com.tr/ekonomi/ilk-drone-gucu-2020de-41328505> accessed 29 October 2021.

[226] STM (n 208)3.

[227] STM (n 218).

[228] STM (n 208) 3.

time.[229] Thus, one might consider that 'target engagement' is not carried out autonomously. Nevertheless, another video advertisement by STM indicates that it may be used both in autonomous and manual modes.[230] According to the video, it has the advantage of an autonomous and precise hit with minimum collateral damage as well as an ability to autonomously fire and forget through the entry of target coordinates.[231] Consequently, it is evident that both the 'target recognition' and 'target engagement' *may* be carried out autonomously.

Following the conclusion above, critical functions are first and foremost functions related to some of the targeting stages of the targeting cycle, including the 'target development' and 'mission planning and execution' stages. Whether or not STM-Kargu has been used in an autonomous mode in Libya is, as defended firmly above, insignificant to the debate on whether it is autonomous. Based on the information on its capabilities in various stages of the targeting cycle, STM-Kargu is an autonomous weapon system with autonomy in its functions related to 'target recognition' and 'target engagement'. The *use* of STM-Kargu in the autonomous mode and to what extent this is illegal are two independent and ongoing issues. The latter will fall outside the scope of this article on defining critical functions of AWS.

E. Concluding definition of AWS and current weapon systems

A legal definition in IHL of a weapon system has the primary purpose of defining the scope of application of legal rules. From the perspective of IHL, what is important is the interaction between the weapon system and the targets that creates the context of questions arising from compliance with IHL. For AWS, autonomy in critical functions is what creates this context and triggers a substantial likelihood of incompliance with IHL. Hence, AWS are weapon systems with autonomy in their critical functions that increase the likelihood of incompliance with IHL.

Autonomy is the ability to operate independently from human control. Critical functions are functions related to targeting which are functions related to targeting and intelligence functions, on occasions that they form an integral part to the engagement with targets and thus, which must be analysed *in casu.* Interoperability is a premature technology to think about autonomy independent of other functions assumed by the system, yet, to the extent that the ultimate technology affects the involvement of humans in the cooperation, functions related to interoperability will also be critical.

This definition is inclusive of some of the current weapon systems besides the above-mentioned example STM-Kargu. The US made air-defence system of the navy ships, the Phalanx, is programmed to engage targets with a speed within a predefined velocity range it detects through its radar system then 'the target threat software makes the decision to engage or not and the priority of engagement'.[232] Although it is intended to operate under human supervision, the interaction between the Phalanx and the targets can be brought about in an autonomous way. The Phalanx has autonomy in its critical functions. The Israeli-made active protection system, Trophy Active Protection System has

[229] Kamer Kurunç, 'BM Raporundaki STM-KARGU-2 iddiaları yetkililerce yalanlandı' (*Savunma Sanayi ST*, 21 June 2021) <https://www.savunmasanayist.com/bm-raporu-KARGU-2-iddialari-yalanlandi/> accessed 29 October 2021.

[230] STM (n 224)

[231] ibid.

[232] Robert H Stoner, 'History and Technology, R2D2 with Attitude: The Story of the Phalanx Close-In Weapons' (*Navweaps*, 2009) <http://www.navweaps.com/index_tech/tech-103.php> accessed 29 October 2021.

a 'man-out-of-the-loop' reaction, requiring an autonomous shooting robot'. [233] These systems are designed to protect 'armoured vehicles against incoming anti-tank missiles or rocket' and they detect, identify, track, and select targets (the incoming tank missiles or rockets) in complete autonomy. By nature, they operate in a speed that exceeds human capabilities[234] to provide better protection, so using them with human supervision is renders the use of the system devoid of utility. Accordingly, it can be safely concluded that these systems also have autonomy in their critical functions and thus, qualify as AWS.

Serious efforts have been made to divert the definition of AWS in order to exclude from the debate the current weapon systems in the fear that a ban on these weapon systems would discourage States to regulate AWS effectively. Many of these systems are used in 'highly structured and predictable environments' 'with very low risk of civilian harm'; they cannot 'dynamically initiate a new targeting goal'; they are under constant supervision by humans; only used in 'defensive' modes and not in 'offensive' modes; designed as 'anti-material' systems as opposed to 'anti-personnel' systems, thus incapable of engaging with 'human or human-inhabited targets'.[235]

Most of these diverting distinctions are about the legality of the use of the AWS than about its definition. Some of these distinctions are about whether the effects of the weapon can be controlled to comply with the indiscriminate weapons rule, such as operating in structured environments with low risks of predictability issues. Some are about a more advanced AWS technology, such as the ability to change goals, and are of limited use considering from the perspective of IHL functions should matter more than the sophistication of the machine. More importantly, some distinctions that add the most confusion are about the use of AWS in a legal way to ensure compliance with IHL and not about the definition of AWS. Take the distinction between anti-material and anti-personnel weapon systems, which is a common way to, so to say, 'excuse' the Phalanx system from the category of an AWS since it is deployed in naval areas with almost no civilian presence. Anti-personnel mines are banned by the 1997 Anti-Personnel Mine Convention whereas anti-vehicle land mines are not. This does not change the fact that anti-vehicle land mines also qualify as 'mines'. A parallel logic can be found in the use of explosive weapons in populated areas. These have been considered illegal due to their indiscriminatory effect if used in populated areas where there are 'concentrations of civilians' be it a city, a town, a village; be it permanent or temporary, such as camps for internally displaced persons (IDPs)'.[236] In areas that are not as populated, their legality does not raise similar concerns. Once again, a consistent way of using of a weapons system, in this case explosive weapons in populated areas, does not change its definition , but does affects its legality.

Limiting the definition excludes some current weapon systems from the overall discussion and undermines the discussions on MHC and other means of improving the legal use of AWS. It also diverts the attention on the precautions and improvements of the

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[233] Rafael, 'Trophy Family: Active Protection Suite for Armored Vehicles' (*Rafael*), 2 <https://www.rafael.co.il/wp-content/uploads/2019/03/Trophy-Family-brochure.pdf> accessed 20 March 2022.

[234] Boulanin and Verbruggen (n 10) 43.

[235] Daniele Amoroso and others,*Autonomy in Weapon Systems: The Military Application of Artificial Intelligence as a Litmus Test for Germany's New Foreign and Security Policy* (Heinrich Böll Foundation 2018) 21.

[236] ICRC, *Explosive Weapons in Populated Areas Humanitarian, Legal, Technical and Military Aspects* (ICRC 2015) 3.

unexpected outcomes of the use of current AWS,[237] such as the misidentification of the Phalanx system of the US warships and opening of a friendly fire.[238]

Ergo, it must be reminded with caution that defining critical functions and developing an enhanced definition of AWS is not an exercise of determining their legality. There are so many weapon systems with autonomous functions that are not being used in the autonomous mode, which does not influence their characterization of having autonomous functions but rather their likelihood of complying with IHL. Under IHL, the definition of the weapons and weapon systems is distinct from the limitations on their use to comply with IHL. Mixing these two have damaging effects on the assessment of the legality of the weapon systems.

V. Conclusion

Autonomy as a technical phenomenon indicates a performance of a task independent of human control. It is the end result of the advances in Artificial Intelligence owing to Machine Learning. This is also what gives autonomy to certain functions of an Autonomous Weapons System.

Autonomy in weapon systems has been explained through the interaction between humans and the weapon system, the complexity of the weapon system, and the functions which enjoy autonomy. The latter is the most relevant for the application of IHL, but it requires further analysis of what the critical functions are that make a weapon system autonomous. Based on a useful SIPRI Report, the functions of a weapon system can be grouped as: (1) Mobility functions; (2) Functions related to health management; (3) Targeting' functions; (4) Intelligence functions; and (5) Interoperability functions. The critical functions are those which trigger substantial likelihood of incompliance with International Humanitarian Law. Whether or not a weapon system is being used in the autonomous mode or does not violate IHL is irrelevant in determining the autonomy in the weapon system. Critical functions are functions related to targeting as well as intelligence functions, which must be analysed *in casu* for that they may also be critical to the extent that they form an integral part to the engagement with targets. To the extent that the ultimate technology affects the involvement of humans in cooperation, functions related to interoperability will also be critical. These are all functions that contribute considerably to the engagement of the weapon system with the target, which creates the context in which questions of IHL arise.

The Turkish weapon system STM-Kargu is a weapon system with an autonomous mode. It has autonomy in its critical function of target development and mission planning and execution. In that, it is an Autonomous Weapons System independent of the question of whether it was used in the autonomous mode, which is disputed, but this dispute is negligible.

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www.grojil.org

237 Jenks (n 59) 27.

238 Bernard Rostker, 'Friendly Fire Incidents' (*GulfLINK Home*, 13 December 2000) <https://gulflink.health.mil/du_ii/du_ii_tabh.htm> accessed 28 August 2021.