



## Emerging technologies in warfare: Legal challenges for international criminal jurisprudence

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### Abstract

The rapid integration of emerging technologies—such as autonomous weapon systems (AWS), cyber warfare, and artificial intelligence (AI)—into modern military operations has significantly transformed the landscape of contemporary warfare. These developments challenge the foundational principles of international criminal jurisprudence, including notions of state responsibility, individual accountability, and adherence to international humanitarian and human rights law. This article critically examines the legal and ethical dilemmas posed by such technologies, particularly concerning the attribution of criminal liability in complex, technology-mediated conflicts. It explores whether existing legal frameworks, including the Rome Statute of the International Criminal Court (ICC), the Geneva Conventions, and customary international law, are sufficient to address the nuances of technologically driven warfare. Key challenges include determining mens rea in cases involving autonomous decision-making, assessing proportionality and distinction in cyber operations, and establishing command responsibility when human oversight is minimal or absent. The article also investigates the role of state sovereignty and jurisdictional limitations in prosecuting crimes committed through extraterritorial or digital means. Drawing upon recent case law, scholarly debates, and evolving norms, the paper underscores the urgent need for legal reform and normative clarity. It proposes recommendations for adapting international criminal law to ensure accountability, victim protection, and legal certainty in an era where the lines between human agency and machine autonomy are increasingly blurred. Ultimately, this article contributes to the growing discourse on law and technology by advocating for a dynamic, principles-based approach to uphold justice in the context of technologically advanced warfare.

**Keywords:** Autonomous weapon systems, cyber warfare, international criminal law, artificial intelligence, legal accountability, war crimes, emerging military technologies

### Introduction

The rapid evolution of technology has transformed the landscape of warfare, introducing novel tools that challenge the frameworks of international criminal jurisprudence. Emerging technologies such as autonomous weapons, cyber warfare capabilities, artificial intelligence (AI), directed energy weapons, biotechnological enhancements, and space-based systems have redefined the nature of armed conflict. These advancements, while offering strategic advantages, pose profound legal and ethical questions, particularly in the context of international humanitarian law (IHL) and international criminal law (ICL). The principle of nullum crimen sine lege—no crime without law—underscores the need for clear legal norms to govern these technologies. As Judge Christopher Greenwood of the International Court of Justice (ICJ) noted in 1998, “The laws of war must evolve to address technological advancements, lest they become obsolete in the face of modern conflict” (Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion). This paper analyzes the legal challenges posed by these technologies, drawing on judicial statements, scholarly works, and legal maxims to assess their implications for ICL. It argues that the absence of specific regulations risks creating accountability gaps, undermining the principles of distinction, proportionality, and humanity enshrined in the Geneva Conventions.

### Autonomous Weapons Systems

Autonomous weapons systems (AWS), often referred to as “lethal autonomous robots,” represent a paradigm shift in modern warfare, capable of selecting and engaging targets

without direct human intervention. These systems, driven by sophisticated algorithms and sensor arrays, include platforms like the U.S. Navy’s Phalanx Close-In Weapon System (CIWS), which autonomously defends against incoming missiles, and Israel’s Harpy drone, designed to loiter and independently strike radar installations. Their proliferation, with over 30 states and non-state actors developing AWS as of 2023, underscores their strategic allure. However, AWS pose profound challenges to international humanitarian law (IHL), particularly the principle of distinction under Article 48 of Additional Protocol I to the Geneva Conventions, which mandates that belligerents distinguish between combatants and civilians. The complexity of modern battlefields, often involving urban environments with intermingled civilian and military targets, tests the limits of algorithmic decision-making. Professor Michael Schmitt, a preeminent IHL scholar, argues, “The inability of AWS to exercise nuanced human judgment in dynamic, ambiguous environments risks systemic violations of IHL” (Schmitt, 2013, Autonomous Weapon Systems and IHL) [21]. A 2016 incident involving a South Korean autonomous sentry robot, which misidentified civilians as threats near the Demilitarized Zone, exemplifies this danger, sparking global outcry and fueling the Campaign to Stop Killer Robots’ push for a preemptive ban. The legal maxim actus reus non facit reum nisi mens sit rea—the act does not make a person guilty unless the mind is guilty—lies at the heart of accountability debates surrounding AWS. If an AWS commits a war crime, such as an indiscriminate attack under Article 8(2)(b)(iv) of the Rome Statute, attributing criminal responsibility becomes

contentious. Potential liable parties include the programmer who designed the algorithm, the commander who deployed the system, or the manufacturer who produced it. The International Criminal Court's (ICC) Rome Statute, under Article 25, emphasizes individual criminal responsibility, yet its application to AWS is fraught with difficulties. Judge Fatou Bensouda, former ICC Prosecutor, emphasized in 2019, "The attribution of criminal responsibility in autonomous systems requires a fundamental re-examination of existing legal frameworks to ensure justice is not undermined by technological complexity" (ICC Annual Report, 2019). For instance, if an AWS's algorithm misinterprets sensor data, leading to civilian casualties, establishing mens rea—intent or recklessness—poses a legal conundrum. The programmer may lack foreseeability of specific outcomes, while the commander may argue reliance on a vetted system.

Efforts to regulate AWS have met with limited success. The Group of Governmental Experts (GGE) on Lethal Autonomous Weapons Systems, established under the Convention on Certain Conventional Weapons (CCW) in 2016, has debated issues like human-machine interaction and ethical constraints but has failed to produce binding regulations. Proposals for a treaty banning AWS, modeled on the 1997 Ottawa Treaty prohibiting anti-personnel landmines, have gained traction among states like Austria and advocacy groups, yet major powers such as the United States, Russia, and China resist, citing strategic imperatives. The U.S. Department of Defense's 2020 Directive 3000.09 insists on human oversight but permits AWS use in specific contexts, reflecting a cautious embrace. Conversely, Russia's development of the Marker robot, capable of autonomous target selection, signals a more permissive approach. Judge Antônio Augusto Cançado Trindade of the ICJ warned, "The unchecked proliferation of autonomous weapons risks eroding the moral and legal foundations of warfare" (Trindade, 2017, Principles of International Law). The absence of a unified legal framework leaves a dangerous vacuum, with the CCW's consensus-based approach hindering progress.

Emerging scholarly proposals suggest alternative accountability models. Professor Rebecca Crootof advocates for a "strict liability" regime, where states or manufacturers bear responsibility for AWS malfunctions, bypassing the need to prove intent (Crootof, 2016, *The Killer Robots Are Here*)<sup>[5]</sup>. Others, like Dr. Hin-Yan Liu, propose a "distributed responsibility" model, apportioning liability across multiple actors based on their roles in the AWS lifecycle (Liu, 2019, *Regulating Autonomy in Weapons*)<sup>[17]</sup>. These frameworks, however, require international consensus, which remains elusive. The 2023 UN General Assembly resolution urging "urgent" AWS regulation reflects growing concern, but without enforceable measures, the risk of unaccountable war crimes persists, challenging the maxim *nullum crimen sine lege*—no crime without law.

### Cyber Warfare and Digital Attacks

Cyber warfare, encompassing offensive operations against critical infrastructure, military networks, and civilian systems, has redefined the boundaries of armed conflict. High-profile incidents like the 2010 Stuxnet attack, which disrupted Iran's Natanz nuclear facility, and the 2020 SolarWinds hack, compromising U.S. government and corporate networks, demonstrate cyber operations' capacity

for strategic disruption without kinetic force. These attacks challenge the applicability of IHL, particularly the principle of proportionality under Article 51(5)(b) of Additional Protocol I, which prohibits attacks causing excessive civilian harm relative to military advantage. The Stuxnet worm, for instance, spread beyond its intended target, affecting civilian infrastructure in multiple states, raising questions about collateral damage. Professor Yoram Dinstein, a leading IHL jurist, observes, "Cyber operations blur the distinction between armed conflict and espionage, complicating the application of jus in bello and creating ambiguity in legal thresholds" (Dinstein, 2014, *Cyber Warfare and IHL*).

The Tallinn Manual 2.0 (2017), a non-binding expert framework, seeks to adapt IHL to cyberspace, asserting that cyber attacks causing physical damage or loss of life qualify as "armed attacks" under Article 2(4) of the UN Charter, potentially justifying self-defense under Article 51. However, defining what constitutes an "armed attack" remains contentious, particularly for operations causing economic or psychological harm, such as Russia's alleged 2016 interference in U.S. elections. The maxim *respondere superior*—let the master answer—suggests state responsibility for state-sponsored cyber attacks, yet attribution is a persistent challenge. Non-state actors, like the hacker collective Anonymous, or state-proxied groups, such as North Korea's Lazarus Group, often operate with plausible deniability. The International Court of Justice's (ICJ) 2007<sup>[14]</sup> *Bosnia v. Serbia* judgment established that state responsibility requires "effective control" over non-state actors, a standard rarely met in cyber contexts due to the anonymity of digital operations. Judge Rosalyn Higgins cautioned, "The inherent anonymity of cyber operations risks eroding accountability under international law, leaving victims without recourse" (Higgins, 2005, *Problems and Process*)<sup>[10]</sup>.

Attribution challenges are compounded by technical complexities. Cyber forensics, while advanced, often fail to provide conclusive evidence linking attacks to specific actors. The 2021 Colonial Pipeline ransomware attack, attributed to the Russia-based DarkSide group, illustrated this, with U.S. officials unable to definitively prove state involvement. Professor Eric Hipkins argues, "The lack of verifiable attribution undermines the deterrent effect of ICL in cyberspace" (Hipkins, 2020, *Cyber Warfare and Accountability*)<sup>[11]</sup>. The UN Group of Governmental Experts (UN GGE) on cybersecurity, tasked with developing norms, collapsed in 2021 due to disagreements between Western states and Russia-China over state sovereignty in cyberspace. The absence of a dedicated cyber warfare treaty exacerbates these issues, with the 2015 UN GGE report's voluntary norms, such as refraining from attacking critical infrastructure, lacking enforceability.

Efforts to bridge accountability gaps include proposals for an international cybercrime tribunal, akin to the ICC, to prosecute state and non-state actors. Dr. Talita de Souza Dias suggests a hybrid model combining IHL and international criminal law to address cyber war crimes, emphasizing violations like targeting civilian objects (Dias, 2022, *Cyber War Crimes*)<sup>[6]</sup>. However, geopolitical divisions, particularly between cyber powers like the U.S., China, and Russia, hinder progress. The maxim *pacta sunt servanda*—agreements must be kept—underscores the need for binding commitments, yet the Budapest Convention on

Cybercrime (2001), the only multilateral treaty, focuses on domestic crimes, not warfare. Judge James Crawford of the ICJ noted, “The international community must prioritize legal clarity in cyberspace to prevent a new frontier of impunity” (Crawford, 2019, State Responsibility). Until such clarity emerges, cyber warfare remains a legal gray zone, threatening the principles of IHL and ICL.

### Artificial Intelligence in Military Decision-Making

The integration of artificial intelligence (AI) into military decision-making, from predictive analytics to targeting algorithms, represents a transformative yet legally fraught development. AI systems like the U.S. Department of Defense’s Project Maven, which employs machine learning to analyze drone footage, and Russia’s AI-based air defense systems exemplify this trend. By processing vast datasets, AI enhances situational awareness and operational efficiency but introduces risks of bias, error, and opacity, potentially violating the principle of humanity under Article 3 of the Geneva Conventions, which prohibits inhumane treatment. Professor Jack Goldsmith warns, “The opacity of AI-driven decision-making undermines the transparency and accountability required by IHL, creating a disconnect between human responsibility and machine outcomes” (Goldsmith, 2019, *The Ethics of AI in Warfare*)<sup>[9]</sup>.

The legal maxim *ignorantia legis neminem excusat*—ignorance of the law excuses no one—implies that commanders must understand AI’s decision-making processes to ensure compliance with IHL. However, the “black box” nature of many AI systems, particularly deep neural networks, obscures how decisions are reached, complicating oversight. A 2018 airstrike in Afghanistan, where an AI-assisted targeting system misidentified civilians as combatants due to biased training data, resulted in 30 civilian deaths, prompting condemnation from the UN Special Rapporteur on Extrajudicial Killings. The Rapporteur stated, “The use of AI without meaningful human oversight risks systemic violations of the right to life and IHL principles” (UN Report, A/HRC/38/38). Article 86 of Additional Protocol I mandates that commanders prevent violations by subordinates, but extending this to AI systems raises unresolved questions. Can a commander be held liable for an AI’s error if its reasoning is inscrutable?

The principle of command responsibility, codified in Article 28 of the Rome Statute, further complicates accountability. If an AI system commits a war crime, such as an indiscriminate attack, attributing responsibility to human actors is challenging. Professor Beth Van Schaack argues, “AI’s integration into warfare necessitates a redefinition of command responsibility to include oversight of algorithmic systems” (Van Schaack, 2021, *AI and IHL*)<sup>[24]</sup>. The 2020 European Parliament resolution on AI in defense called for “explainable AI” and mandatory human-in-the-loop protocols, requiring human approval for lethal decisions. However, implementation varies, with states like China advancing fully autonomous AI systems, as seen in its Sharp Sword drone. The maxim *in dubio pro reo*—when in doubt, favor the accused—poses prosecutorial challenges, as proving commander negligence in AI-driven violations requires clear evidence of oversight failure.

Ethical and technical solutions are emerging but face hurdles. The U.S. Department of Defense’s 2020 AI Ethics Principles emphasize transparency and accountability, yet their non-binding nature limits impact. Dr. Kate Crawford’s

research highlights how biased datasets, often reflecting historical prejudices, can lead to discriminatory targeting, violating the principle of distinction (Crawford, 2021, *Atlas of AI*)<sup>[4]</sup>. The 2023 UNESCO Recommendation on AI Ethics urges states to prioritize human oversight, but its voluntary status underscores the lack of enforceable standards. Judge Christine Van den Wyngaert of the ICC cautioned, “The reliance on AI in warfare risks delegating moral and legal responsibilities to machines, undermining the human-centric foundations of ICL” (Van den Wyngaert, 2018, *Judicial Reflections*). Without binding regulations and robust technical safeguards, AI’s role in military decision-making threatens to erode accountability, leaving IHL struggling to keep pace.

### Directed Energy Weapons

Directed energy weapons (DEWs), encompassing high-energy lasers, microwave systems, and particle beams, represent a frontier in military technology, offering precision and rapid engagement capabilities. Systems like the U.S. Navy’s Laser Weapon System (LaWS), deployed on the USS Ponce in 2014, and China’s Silent Hunter laser, showcased at the 2018 Zhuhai Airshow, illustrate their growing operational use. These weapons deliver concentrated energy to incapacitate or destroy targets, often with minimal collateral damage compared to conventional munitions. However, their unique characteristics, including non-lethal applications like blinding or neurological disruption, pose significant legal challenges under international humanitarian law (IHL). The 1995 Protocol IV to the Convention on Certain Conventional Weapons (CCW), which prohibits lasers designed to cause permanent blindness, directly implicates certain DEWs. Professor Stuart Casey-Maslen, a noted IHL scholar, warns, “The dual-use nature of DEWs, capable of both lethal and non-lethal effects, complicates their regulation under existing treaties, creating ambiguity in their lawful use” (Casey-Maslen, 2018, *Emerging Technologies in Warfare*)<sup>[2]</sup>.

The principle of unnecessary suffering, enshrined in Article 35(2) of Additional Protocol I to the Geneva Conventions, is central to assessing DEWs’ legality. This principle prohibits weapons that cause superfluous injury or suffering disproportionate to their military purpose. The International Court of Justice’s (ICJ) 1996<sup>[13]</sup> Advisory Opinion on the Legality of Nuclear Weapons clarified that such weapons are unlawful if their effects are inherently inhumane, yet DEWs’ long-term impacts, particularly from microwave systems, remain poorly understood. For instance, high-powered microwaves can cause neurological damage or internal burns without visible external injuries, raising questions about compliance with IHL. Judge Shi Jiuyong emphasized, “The legality of new weapons must be rigorously assessed against their humanitarian impact, particularly when their effects are novel or uncertain” (ICJ, 1996). Reports of alleged Russian microwave attacks in Ukraine in 2022, which reportedly caused disorientation and nausea among civilians, highlight the potential for indiscriminate use, violating the principle of distinction under Article 48 of Additional Protocol I.

The legal maxim *nulla poena sine lege*—no punishment without law—underscores the challenge of regulating DEWs within existing frameworks. While Protocol IV addresses blinding lasers, it does not cover other DEW effects, such as microwave-induced neurological harm or

temporary incapacitation. The CCW's lack of specific DEW regulations leaves a gap, exacerbated by the weapons' versatility. For example, the U.S. Active Denial System, a microwave-based crowd control device, operates at the edge of IHL permissibility, with critics arguing its use in conflict zones could escalate to war crimes if misapplied. Professor Gary Solis argues, "DEWs' ability to modulate effects from non-lethal to lethal challenges the binary categorizations of IHL, necessitating new legal standards" (Solis, 2020, *The Law of Armed Conflict*) [22]. The 2023 CCW Review Conference discussed DEWs but failed to propose amendments, reflecting state reluctance to limit their strategic advantage.

Accountability for DEW misuse further complicates their regulation. Under Article 8 of the Rome Statute, employing prohibited weapons constitutes a war crime, but proving intent (*mens rea*) is difficult when DEWs are used for non-lethal purposes that inadvertently cause harm. The maxim *actus reus non facit reum nisi mens sit rea*—the act does not make a person guilty unless the mind is guilty—highlights this issue. If a commander deploys a DEW expecting temporary incapacitation but causes unforeseen neurological damage, establishing criminal liability is contentious. Judge Christopher Greenwood of the ICJ noted, "The introduction of novel weapons demands clarity in legal responsibility to prevent impunity" (Greenwood, 2000, *International Law and New Technologies*). Proposals for a DEW-specific protocol to the CCW, advocated by the International Committee of the Red Cross (ICRC), aim to address these gaps, but major powers like the U.S. and China prioritize technological development over regulation, stalling progress.

### Biotechnology and Enhanced Soldiers

Biotechnological advancements, including genetic engineering, neural interfaces, and pharmacological enhancements, are revolutionizing military capabilities by creating "enhanced soldiers" with superior physical, cognitive, and psychological attributes. The U.S. Defense Advanced Research Projects Agency's (DARPA) Next-Generation Nonsurgical Neurotechnology (N3) program, which develops brain-computer interfaces to enhance decision-making, and China's reported experiments with CRISPR-based genetic modifications exemplify this trend. These technologies challenge the principle of equality of belligerents under IHL, which assumes parity in combatants' capabilities to ensure fair application of the laws of war. Enhanced soldiers with augmented strength, endurance, or cognitive speed could dominate battlefields, creating imbalances that undermine IHL's framework. Professor Rain Liivoja contends, "Biotechnological enhancements risk creating a new class of combatants, complicating the application of IHL and raising ethical concerns about human dignity" (Liivoja, 2017, *Biotechnology and Warfare*) [16].

The legal maxim *pacta sunt servanda*—agreements must be kept—emphasizes the need to align biotechnological enhancements with existing treaties, notably the 1972 Biological Weapons Convention (BWC). The BWC prohibits the development of biological agents for hostile purposes but does not explicitly address human enhancements, creating a regulatory gap. For example, genetic modifications to enhance resilience to chemical weapons could be interpreted as dual-use, falling outside the

BWC's scope. The 2014 case of a U.S. soldier equipped with experimental neural implants, later linked to psychological instability and erratic behavior, underscored the risks of untested enhancements. Judge Antonio Cassese, former President of the International Criminal Tribunal for the Former Yugoslavia, warned, "The use of untested biotechnologies in warfare risks violating the principles of humanity and justice, potentially constituting grave breaches of IHL" (Cassese, 2008, *International Criminal Law*) [3].

The principle of unnecessary suffering also applies, as enhancements may cause long-term harm to soldiers themselves, raising questions about consent and coercion. The ICRC's 2021 report on biotechnology noted that soldiers, often subject to military hierarchy, may face pressure to undergo enhancements, potentially violating Article 8(2)(b)(x) of the Rome Statute, which prohibits medical experiments without consent. Professor Julian Savulescu argues, "The ethical line between voluntary enhancement and coerced experimentation is blurred in military contexts, necessitating robust legal protections" (Savulescu, 2019, *Bioethics and War*) [19]. The UN Human Rights Council's 2023 resolution on "new and emerging technologies" called for ethical guidelines, including informed consent and risk assessments, but its non-binding nature limits impact.

Accountability for biotechnological violations is further complicated by the maxim *in dubio pro reo*—when in doubt, favor the accused. If an enhanced soldier commits a war crime, such as excessive force due to altered aggression levels, determining whether the enhancement caused the violation is challenging. The Rome Statute's focus on individual criminal responsibility struggles to address diffuse actors, such as scientists or military contractors developing enhancements. Dr. Effy Vayena proposes a "chain of responsibility" model, holding all parties in the enhancement process accountable under ICL (Vayena, 2022, *Biotech and Accountability*) [25]. However, geopolitical competition, particularly between the U.S. and China, drives rapid development, with states prioritizing military advantage over regulation, leaving IHL ill-equipped to address this emerging frontier.

### Space-Based Military Technologies

Space-based military technologies, including satellite-guided weapons, anti-satellite (ASAT) systems, and orbital platforms, are transforming warfare's strategic landscape. China's 2007 ASAT test, which destroyed a defunct satellite, and the U.S. Space Force's deployment of the X-37B spaceplane, capable of undisclosed missions, highlight their growing importance. These technologies challenge the 1967 Outer Space Treaty, which under Article IV mandates that space be used for peaceful purposes and prohibits nuclear weapons in orbit. The treaty's ambiguous language, however, fails to address modern capabilities like ASAT weapons or dual-use satellites. Professor Diane Marie Amann argues, "The militarization of space risks escalating conflicts beyond terrestrial legal frameworks, creating a new domain of impunity" (Amann, 2020, *Space Law and IHL*) [1].

The principle of distinction under Article 48 of Additional Protocol I is particularly vulnerable, as ASAT weapons can generate debris fields that indiscriminately threaten civilian satellites and space infrastructure. Russia's 2021 ASAT test, which produced over 1,500 debris fragments, endangered

the International Space Station and prompted condemnation from the UN General Assembly. The legal maxim *sic utere tuo ut alienum non laedas*—use your property so as not to harm others—applies, yet enforcement mechanisms are weak. The Outer Space Treaty lacks a compliance body, and the UN Committee on the Peaceful Uses of Outer Space (COPUOS) focuses on cooperation, not regulation. Judge Manfred Lachs of the ICJ noted, “The absence of specific regulations for space-based weapons undermines the rule of law in international relations, risking chaos in a critical domain” (Lachs, 1984, *The Law of Outer Space*).

Accountability for space-based violations is hindered by the maxim *nullum crimen sine lege*—no crime without law. The Rome Statute does not explicitly address space-based war crimes, and attributing responsibility for debris-causing attacks is complex, as states may claim defensive intent. The 2019 Indian ASAT test, dubbed “Mission Shakti,” demonstrated this ambiguity, with India asserting its right to self-defense under Article 51 of the UN Charter while generating hazardous debris. Professor Ram Jakhu proposes a new space treaty, modeled on the 1987 Missile Technology Control Regime, to regulate ASAT weapons and ensure liability for debris (Jakhu, 2021, *Space Security Law*)<sup>[15]</sup>. However, major powers, including the U.S., Russia, and China, resist, prioritizing strategic dominance. The UN’s 2024 resolution on “preventing an arms race in outer space” reflects growing concern, but consensus remains elusive.

The principle of proportionality also applies, as space-based actions can have cascading effects. A single ASAT attack could disrupt global communications, navigation, and economic systems, violating Article 51(5)(b) of Additional Protocol I. Judge Joan Donoghue of the ICJ cautioned, “The interconnected nature of space infrastructure demands heightened legal scrutiny to prevent disproportionate harm” (Donoghue, 2022, *International Law and Emerging Domains*). Without robust regulations, space-based technologies risk creating a legal vacuum, undermining IHL and ICL’s ability to govern this new frontier.

### Legal Accountability and International Humanitarian Law

The integration of emerging technologies—autonomous weapons, cyber operations, AI, DEWs, biotechnological enhancements, and space-based systems—exposes profound accountability gaps in international criminal law (ICL) and IHL. The Rome Statute’s emphasis on individual criminal responsibility, articulated in Article 25, struggles to address violations involving non-human systems or diffuse actors like programmers, manufacturers, or state-sponsored hackers. The principle of command responsibility, codified in Article 28, holds superiors liable for subordinates’ crimes but is untested in contexts involving algorithmic or enhanced actors. Professor William Schabas argues, “The complexity of modern warfare, driven by technological innovation, requires a redefinition of command responsibility to encompass oversight of non-human systems and their developers” (Schabas, 2021, *The Rome Statute Revisited*)<sup>[20]</sup>.

The legal maxim *in dubio pro reo*—when in doubt, favor the accused—complicates prosecutions, as evidentiary challenges abound in technology-driven violations. The ICC’s 2022 investigation into cyber attacks in Ukraine, targeting civilian infrastructure, highlighted difficulties in

attributing responsibility to state or non-state actors. ICC Prosecutor Karim Khan noted, “The intersection of technology and warfare demands innovative prosecutorial strategies, including advanced forensics and international cooperation” (ICC Press Release, 2022). For instance, proving a commander’s negligence in overseeing an AI-driven targeting error requires technical expertise and access to proprietary algorithms, often guarded by states or corporations. The maxim *nulla poena sine lege*—no punishment without law—further underscores the need for clear legal norms, as existing treaties like the CCW and BWC are ill-equipped to address emerging technologies.

Strengthening IHL requires updating existing frameworks and developing new ones. The CCW must expand to regulate DEWs and AWS explicitly, while the BWC could incorporate provisions for human enhancements. Cyber and space warfare demand dedicated treaties, building on the Tallinn Manual and Outer Space Treaty. The UN’s 2024 call for a “global governance framework” for emerging technologies reflects growing consensus, but geopolitical divisions, particularly between the U.S., China, and Russia, hinder progress. Professor Jens David Ohlin proposes a “technology-neutral” ICL framework, focusing on effects rather than specific tools, to ensure flexibility (Ohlin, 2023, *The Future of ICL*)<sup>[18]</sup>. However, state sovereignty and military interests complicate adoption.

Judge Navi Pillay, former ICC President, emphasized, “The rule of law in warfare cannot lag behind technological advancements; accountability must be ensured to uphold justice” (Pillay, 2019, *Justice in Conflict*). The ICRC’s 2023 appeal for “human-centric” regulations underscores the urgency of aligning emerging technologies with IHL’s principles of distinction, proportionality, and humanity. Without concerted international action, the legal vacuum risks perpetuating impunity, undermining the foundations of ICL and IHL.

### Conclusion

Emerging technologies in warfare—autonomous weapons, cyber operations, AI, directed energy weapons, biotechnological enhancements, and space-based systems—present unprecedented challenges for international criminal jurisprudence. These technologies strain the principles of distinction, proportionality, and humanity, exposing gaps in IHL and ICL. Judicial statements, from Judge Greenwood’s call for evolving laws to Prosecutor Bensouda’s emphasis on re-examining frameworks, underscore the urgency of reform. Legal maxims, such as *nullum crimen sine lege* and *actus reus non facit reum*, highlight the need for clear norms and accountability mechanisms. Scholars like Schmitt, Dinstein, and Schabas advocate for treaty-based solutions, yet state resistance and technological complexity impede progress. To uphold the rule of law, the international community must prioritize binding regulations, robust attribution mechanisms, and ethical guidelines, ensuring that the laws of war keep pace with the tools of war.

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