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Laser and Directed Energy Weapons within International Humanitarian Law

The History of the Utilisation of Light and Direct Energy Weapons as a Military Weapon

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Abstract

Since the conception of conflict among humanity, the need to evolve one's own arsenal to gain the advantage on the enemy has become an irrefutable necessity. Be it a sharper stick or a larger bomb, warfare evolves to both act and counter-act with increasing efficiency, precision and destructive power. For the last few decades, we have seen the emergence of laser weapons as a tool for militaries across the world, be it as a tool to assist ballistic weapons, an offensive weapon with the power to blind or even a defensive weapon to remove the threat of missiles. This paper not only seeks to assess the history of laser development, but also the principles of superfluous injury along with military necessity and whether they are able to co-exist on the battlefield. Whilst much of this paper seeks to be explorative of the past, each Chapter addresses a particular area of warfare that would need to be taken into consideration for future laser systems with any accompanying international legislation that will restrict their uses, particularly if laser weapons are to be targeted directly at combatants. This will form the basis of the final purpose of the Thesis, which is to create the foundation for a pro-active Protocol limiting the use of energy weapons before they become commonplace. Speculating into the future of laser weapons may find us relying on the past, as the legislation prohibiting blinding lasers may prove most useful when predicting the path that these optical weapons may take, whilst also providing the structure for our own Protocol. Whilst this theoretical Protocol does not pretend to be watertight, it does attempt to incorporate the most important elements of consideration within the laws of armed combat.

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1 Introduction

"Friends, as they say, may come and go, but high-powered laser weapons are forever" - Mark Walden

The following exploration of the military's use of laser powered weapons seeks to move from those that have established themselves as useful aids to physical weapons, such as targeting lasers and laser-guided missiles, through the evolutionary timeline to the more experimental speculations of future warfare. Therefore, lasers that are used both for guidance systems and those that may be capable of a more offensive strike will be identified as such. One may make the mistake of considering guiding lasers to have no conflict with international humanitarian law (IHL), however their consequential ability to damage the human eye has seen rise to one of the most important pieces of international legislation. The question of whether this precise means of guidance, in its consideration on the principle of targeting, outweighs the unnecessary collateral damage it has the potential of causing will be both legally and philosophically discussed. The scientific process of creating the laser beam itself has changed since its inception, from various gaseous combustions in the 20th century to the solid-state and optical beams of the present. This Thesis will not only look at the scientific beginnings of the light beam itself, but to its ability to be harnessed and directed for specific and tailored purposes in a military context. Naturally, as many inventions are, the true optical laser was born from a desire to gain the technological edge, as tensions between the superpowers of the world rose after their short-lived alliance at the end of 1945. Many failures of laser technology from the Cold War can be helpful in understanding the barriers to complete true Direct Energy Weapons (DEWs) in the future, as some forces of nature that surround us can only be broken with an unstable level of Wattage. In this way, it will be important to evaluate the practicality of all these weapons, as the more ambitious laser projects have ultimately failed due to operating failures. Behind failed ambitions still lies a desire, one that may be rekindled when the shackles of the technological-era may be broken.

As each Chapter focusses on a different area of laser implementation, so too will the themes overlap that will link their usage to the wider picture of IHL. Indeed, the move toward a less lawless scope of warfare will be touched upon, where superfluous injury will be detailed. This idea of minimising personal suffering, combined with the more strategic coherence to military necessity, will provide the themes in which we theorise as to the part that lasers have, and will have, played in our global theatre. Whether a laser is used for personnel or non-personnel use will be critical in evidencing whether there are considerations to be made as to how it is used, along with its lethality. If a laser can prove itself to discriminate effectively, whilst not unduly

causing the target to suffer, it could present itself as a greater tool when navigating the lines and grey areas of *Jus In Bello*. Moving away from personnel uses, non-combatant usage hopes to uncover the means in which airborne and ballistic threats are countered through the use of heat and the diverse range of lasers that can be deployed in tactical locations to nullify the most devastating means of warfare. As with all areas of IHL, it may be the non-lethal methods that are prohibited the most, such as the Protocol on Blinding Lasers that will form the basis of our futuristic speculation. When we explore the potential for future lethal-capable lasers in the latter half of this Thesis, these may have some criteria to fulfil if they are not to be fully prohibited so as to not compromise our hypothetical customary law. This is not to say our prediction will be a finalised piece, where loopholes and workarounds will be discussed and the forms they may take in a realistic scenario.

In coming to this conclusion, each Chapter of this Thesis will play its part. Whilst the themes in each Chapter may be entirely separate in their nature and scope, each will link to create the final argument in Chapter 5 as to the use of laser weapons in future warfare. Chapter 2 focuses on a historical assessment of lasers, rather than the moral or legal implications of their implementation. Learning from historical flashpoints will allow a more accurate prediction to be made as to their future use or purpose. Chapter 3 looks more to the progression of the laws of armed conflict (LoAC) and the morality of militaristic decision-making, combining co-dependent principles such as superfluous injury, military necessity and proportionality. This Chapter will not specifically look at laser warfare, rather incorporate both legal and philosophical stances as to the general application of some of the most important considerations to be observed when conducting operations on the battlefield. All these principles will be brought together in our final theoretical evaluation on the experimental nature of laser weapons in particular. Chapter 4 will demonstrate the effectiveness of pro-active law-making and why it is essential that this is an area of IHL that requires forethought rather than a reaction to an event/s that has already left a permanent effect on hostilities between parties. This Chapter will be purely based on the wording and impact of this piece of legislation, assessed from a legal viewpoint rather than drawing upon scholarly thought from fields outside the realm of law. This should construct a basis for a hypothetical piece of legislation to be drafted in the subsequent chapter. Final thoughts will be reflected in a Conclusion that looks more to the practicality of the proposed legislation in a contextual sense, particularly in a world where the prerogative of certain parties is victory at any cost rather than adhering to a universal set of principles.

2 Concept of Light as a Weapon and Early Uses

Before looking at more conventional methods of utilising light, either as a weapon or as a tool, we will first delve into its history and first known applications. Our first analysis may be more speculative in nature, but will lend itself to the principle of bending light on demand, or rather the idea thereof. Whether there is absolute truth in the tale or not of the great physician Archimedes, this would have been the earliest known example of a 'laser', with the radiation of the sun as its destructive element. Whilst this analysis would be set in a time that predated the infancy of IHL by at least two millennia, the true excitement into lasers and their military function was evident by the early 1960s, in a time when domestic security was determined by the show of force a nation could demonstrate. The early science of optical lasers will be approached from a militaristic viewpoint, and the benefits that such unprecedented accuracy could hope to achieve. The last decade of the Cold War was perhaps the most adventurous in regard to prospective application, as President Reagan hoped to rival Archimedes' ambition for bending light, this time on a global and orbital scale. Ultimately culminating in little more than a school science project for the President, the theorising behind the need for a global defence network is just as relevant today as it was then. Whilst the aforementioned sections will not rely so heavily on cross-examination with IHL, which will be addressed further in this Thesis, these sections seek to provide a basic overview of what a laser is, how it is created and for what purpose it would be developed for.

2.1 Archimedes Solar Ray

> *"Give me a lever long enough and a fulcrum on which to place it, and I shall move the world."*
> *- Archimedes*

Although the ability to harness light and direct it as a laser beam may seem a modern utility, the knowledge of focusing light as a weapon for military uses can be traced back as far as the time of Archimedes. The Archimedes Solar Ray, also referred to as the Archimedes Death Ray due to its destructive purpose, is a tale from circa 212 BC which portrayed the first application of harnessing light energy as a weapon and applying it on the battlefield. As the Roman Empire expanded and laid siege to his home of Syracuse in Sicily, the ancient Greek mathematician sought to repel the invading forces with his intellect and knowledge of physics.

Aside from the 'Giant Iron Claw',[1] that would grasp the Roman ships and drop them fatally back into the waters, or the arsenal of catapults that would hurl projectiles from the safety of the city, he also manifested a Solar Ray from his geometrical imagination. This contraption was a series of ancient bronze mirrors lined along the walls of Syracuse that reflected light from the sun onto the plywood hulls of the Roman ships that would moor themselves at the Sicilian ports.[2] With a supposed maximum distance of 300 metres away, this collective of mirrors would ignite the Roman ships in a lethal fashion as the concentrated power of the sun burned its way through the helpless vessels.

Figure 1 – A bronze mirror reflects light from the sun onto a Roman galley, from the walls of Syracuse.

Indeed, the accuracy behind the tale remains disputed, with many attempting to debunk the claim of Archimedes' ability to ignite the ships that came to Syracuse. Even notable thinkers such as Descartes doubted the tale, looking not only to the lack of immediate reference to the mirrors after the battle but to the impracticality of directing enough assistants to effectively co-ordinate the reflecting panels. Furthermore, the first account of the 'Death Ray' came three and a half centuries after the Roman invasion from Greek physician Aelius Galenus. Questions arose surrounding the shape the glass took, whether it was curved or hexagonal, how long it would take to burn through the galleys and whether Archimedes had the necessary equipment to create these contraptions. Historians and Scientists alike who have delved into replicated

[1] T. Chondros, *Archimedes (287-212 BC): Distinguished Figures in Mechanism and Machine Science* (Springer, Dordrecht 2007) pp.10-15

[2] T. Africa, *Archimedes Through the Looking-Glass* (The Classical World Vol.68 No.5 1975) pp. 305-306

experiments, namely John Scott, have upheld the plausibility of this form of defence.[3] With every scholarly article that seeks to preserve the truth of the Archimedes death ray, there exists several papers claiming it to be "exceedingly doubtful".[4] As this Thesis will, by its nature, rely on the science behind laser warfare, we can assess the likelihood of the Solar Ray's success using calculations that may prove useful later in the essay when describing modern lasers. If we were to assume that the timber hulls were constructed from oak, which would have had a higher moisture content due to their time at sea, it would be reasonable to expect a combustion temperature of circa 500°C.[5] Incident flux, also known as radiative flux, is the energy an object receives (per second). It has been assumed that the minimum incident flux that would be needed for these mirrors to be successful would be anywhere between 60-80 kW/m² (kilowatts per metre squared).[6] If the conditions of the weather were perfect, with an assumed peak flux of 300 W/m² per mirror, it would have required at least 200 of them in formation to enflame a single Roman ship. Post-2000 mock-ups to test this case with a similar number of mirrors have held mixed results, with anywhere from no combustion to partial flames being visible.[7] In this way, it was very unlikely that Archimedes destroyed the Roman fleet in one fell swoop of his man-powered laser, but more likely he was able to deter the attacks with blinding light from the sun. This should be remembered for when we encounter blinding lasers in Chapter 4, whilst applying the principles of humane warfare from the following Chapter 3.

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[3] J. Scott, *On the Burning Mirrors of Archimedes, and on the Concentration of Light produced by Reflectors* (Proceedings of the Royal Society of Edinburgh, Vol.6 1869) pp. 232 - 235

[4] M. Clagett, *Archimedes in the Middle Ages* (The Arabo-Latin Tradition, Madison: University of Wisconsin Vol.1 1964) pp. 214

[5] V. Babushkas, *Ignition of Wood: A Review of the State of the Art* (Journal of Fire Protection Engineering Vol.12(3) 2002) pp.163-171

[6] C. Ho, *Application of Concentrating Solar Power: Archimedes Solar (Death) Ray* (Sandia National Lab, Albuquerque NM 2014) pp. 6-10

[7] Both MIT and Mythbusters have attempted to recreate the events of the Syracuse harbour, with results that have had no definitive answer.

2.2 Early Laser Technology

From solid-state to flowing gas lasers, the public declaration of this tool can be traced back to the innovation that was escalated as a result of the Cold War. Specifically, the Hughes Aircraft Company that produced the first directed emission of optical radiation in the early 1960s. This was first bred from the Ammonia-based reactions that were used in the microwave oscillator in 1951, which were then extended to other wavelengths through substantial military contracts. It was not long after that the Department of Defense furthered their budget to coincide with this new direction of technology, pouring millions of USD into R&D.[8] This was originally referred to as the 'optical maser', and sparked debate in all departments of the military as to its potential use, be it ground, sea or air combat, each with its own bespoke purpose. Indeed, as quoted by the head of Army Ordnance Missile Command:[9]

> *"...I feel, as others do here, that the LASER may be the biggest breakthrough in the weapons area since the atomic bomb"*

The gravity of this statement should not be understated, given its periodic context, as it was the invention of the atomic bomb that brought about the swift and destructive end of World War II. As funding was poured into laser projects from military divisions from every department, it was apparent that this technology would provide precision and targeting to a level that would make microwave radar redundant.

In this way, the ability to harness lasers as a targeting and range-finding tool is by far the most popular and successful use of both the early and modern laser. As their purpose is to assist the offensive weapon, rather than cause the damage in of itself, the energy output does not need to be significant. These can operate for a range of up to 25km, where the increased demand in range would come with a larger rangefinder, which can be anywhere from a small handheld device to a mounted device on a vehicle. For a firearm, these lasers are not unlike the laser pointers that would be available to the consumer market. These lasers are visible to the naked eye when used conventionally, however they may take the form of an infrared beam for covert operations so that they may be used in conjunction with night-vision goggles. For weapons that

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[8] R. Seidel, *From Glow to Flow: A History of Military Laser Research and Development* (Historical Studies in the Physical and Biological Sciences Vol.18(1) 1987) pp.111-113

[9] Letter from Major General A. Schomburg to Lieutenant General J.H. Hinrichs, 16th January 1962, history office, US Army Missile Command, Redstone Arsenal, Huntsville.

require long-distance precision, laser-range finders are used in this way by sending a pulse of light and measuring how long it takes for the pulse to return to the device. This differs slightly from the laser-designator, which is used for heavier ammunitions such as missiles and artillery. Instead of returning the pulse of light to the device, it is reflected into the sky where it is picked up by the laser-seeking munition. This allows the launched munition to trace its path to the centre of the emitted signal. Both laser range finders and designators have the added benefit of an invisible beam, which ensures its detection is unlikely. The only real defence to laser-targeting is to equip absorptive coatings to personnel and equipment so that the beam of light is unable to reflect and provide coordinates. A Russian attempt at an anti-laser shield is referred to later in regard to the laser-designator, attached to their tanks and helicopters to prevent precision artillery strikes. Some of these utilisations will be discussed due to their ability to permanently blind if used illegitimately, such as the range-finder, and other laser-based tools such as the 'dazzler' in Chapter 4.

2.3 "Star Wars" and the Counter to Anti-Ballistic Missiles

In the last decade, new laser-defence systems have been unveiled that allow for the destruction of small airborne targets, through burning out motors or causing explosive material within the target to combust. However, although only truly practical in modern application, the idea of lasers to neutralise airborne threats can also be dated back to the Cold War. To destroy a ballistic missile on the other side of the planet, the laser itself would only truly be effective from orbit, harkening back to Reagan's 'Strategic Defense Initiative' (SDI), and the Space-Based Interceptors (SBI) that were planned to destabilise the Mutually Assured Destruction (MAD) doctrine. This was infamously nicknamed the *'Star Wars Program'*, due to its futuristic promise of particle-beams and space-based defence platforms. Despite talks of this in the 1980s, space warfare has never truly come to fruition, with the vast majority of Reagan's R&D yielding no fruit. Although, when such technology is more commonplace, those who control the orbital satellites that circle the globe will have an advantage beyond any conventional weapon. Even before the Reagan administration, the U.S. Air Force's Director of Operational Requirements predicted the desire for advancement beyond the atmosphere:[10]

> *"Forces employing space systems offer the U.S. means for maintaining and extending aerospace superiority"*

[10] Document from Major General B. Holloway, "Required operational capability in space, 1965-1975", Required Operational Capability 30th September 1960, Air Force History Centre, Montgomery, Alabama.

In this way, the ability to create the most effective laser guided counter-measure for ballistic offences is simply the most modern effort in dating the weapons of the past. However, in a strong defence therein may lay the strongest offence, as if a threat is to be entirely neutralised then it may allow for retaliation with no threat of harm. Just as the Anti-Ballistic Missile (ABM) Treaty between the US and Soviet Union sought to bring about a limit to the capacity of each superpower to deploy countermeasures to Inter-Continental Ballistic Missiles (ICBM), we may see similar discussions if lasers are to become so competent as to destroy ballistic threats with ease. The reasons behind the ABM treaty were that if either side were to reduce their vulnerability to such an extent, it would remove the doctrine of MAD.

Sometimes it may be extremely costly, depending on the source of the laser, to operate this form of aerial defence system, which would make it impractical. As a payoff, this may allow for a stronger beam, which in itself would be more effective in disabling targets. Sacrificing power for cost, alternatively, may bring about a laser weapon more suitable for consistent use on the battlefield, but one that struggles in harsh weather conditions or against more competent projectiles. No single laser aerial-defence system has made itself the clear victor yet, as each face incredible hurdles to finding a balance between cost-effectiveness and military advantage. It is not obscene to consider a future where laser-guided defence systems will become so competent that they could potentially remove nuclear threats at an incredibly high altitude, thus shifting the balance of global power heavily in the favour of one nation if such technology was unilateral. Whilst Eastern superpowers have claimed significant growth in their capabilities of hypersonic missiles, the demand for a protective weapon that can travel at the speed of light has risen greatly, as no physical object could hope to evade a beam of light, regardless of its Mach speed. At the time of writing this Thesis, the Chinese military successfully tested a hypersonic missile that orbited the earth, then landed within 20 miles of its intended location, much to the surprise of US intelligence.[11] This was soon followed by the Russian Satan-2 hypersonic missile, no doubt as a warning to NATO-aligned countries who would look to undermine their invasion of Ukraine. To intercept a missile of this capacity is far easier said than done, as the kW output of the laser itself would need to be far greater than those that currently destroy drones. Even a decade ago, The Round Table of Sanremo acknowledged the danger and importance that space warfare could pose:[12]

[11] Bloomberg Article, "China's Hypersonic Test Showed Unprecedented Capability", 22 November 2021

[12] M. Bourbonnière, *Law, technology and the conduct of hostilities in space* (34th Round Table on Current Issues of International Humanitarian Law, International Humanitarian Law and New Weapon Technologies, 2011) pp. 159-162

"Contemporary military doctrine articulates that the ground superiority is contingent upon air superiority and air superiority is itself contingent upon the dominance of the space medium"

3 Superfluous Injury and Military Necessity within International Humanitarian Law

Having looked at the history of laser weapons, along with their development and purpose, we must now assess the areas of IHL that this Thesis hopes to apply to usage. To understand how laser technology may fit into our concept of a modern battlefield, let us primarily evaluate the past and how IHL came to be. Within this Chapter, a discussion of why the first pieces of prohibitive and restrictive legislation were drafted shall be presented in a historical context, whilst the over-arching themes of military necessity and superfluous injury will be cross-examined contextually in regard to laser utilities. Both the conflict that lasers may cause with IHL, which would require greater consideration as to the law that restricts them and the means in which they could follow the tight line of legal warfare, will be discussed. Although the laws as we have come to recognise them only truly emerged with the St Petersburg Declaration halfway through the 19th century, restrictions on armed conflict can be traced back to the ancient Laws of Manu and the denouncement of the crossbow by the Lateran Council.[13] Whether these decisions were made on a humanitarian basis or for self-preservation, it is still remarkable to consider that the barbaric nature of conflict was restricted in any sense at a time when the international scrutiny of military-ethics would have been non-existent.

3.1 Humane Warfare and Superfluous Injury

Despite the limited scope of the eleven paragraphs set out by the St Petersburg Declaration in 1868, it is the principles of warfare that it touched upon that have seen it grow and develop the modern laws of armed conflict as they are today. Whilst means and methods were discussed, such as the incredibly narrow limitation of explosive bullets under 400g, the idea of limiting weapons that went above the necessary force to secure victory is still very much at the forefront of humanitarian discussion in the present day.

Declaration

"…at which the necessities of war ought to yield to the requirements of humanity…That the progress of civilization should have the effect of alleviating as much as possible the calamities of war…"

These concepts of quality of life, through which a more humane perspective on combatants and protective stance of non-combatants was developed, was reaffirmed many times in the 20th

[13] A. Peters, *Blinding Laser Weapons: New Limits on the Technology of Warfare* (Loyola L.A. Vol.18 No.4 733 1996) pp. 733

century's equivalent international legislation.[14] Until this point in time, discourse surrounding limiting warfare across the warring nations of the world had mainly been proposals for disarmament and partial reductions in the number of armed forces, rather than the means these troops would deploy. In this way, the scope focussed on the threat to the individual, rather than those who had everything to lose should the individuals fail in battle.

Obviously, the drafters of this legislation from the mid-19th century would not have even fathomed the technology available to the militaries of the world in the present day, with air power and autonomous weapons dominating the theatre of battle. Despite this, we can still draw a comparison with the explosive bullet that was prohibited by this declaration and the blinding laser already briefly touched upon. Just as this bullet would cause superfluous injury to the combatant, by exploding on contact with the soft tissue into many fragments which would riddle the victim, a laser that was designed to blind the target goes far above the military need for achieving victory. Although it may still seem cruel to state, the weapons that discriminate most efficiently and destroy their intended target as quickly as possible are those that are frowned least upon in the rules of engagement. In this way, not only are they able to differentiate between combatant and non-combatant, they also provide a quick end to those who have chosen to participate in warfare. If the chosen means of weapon does not cause death to the combatant, at the very least it should not cause grievous wounds that are untreatable by conventional medical services, as once a combatant is injured and unable to fight they assume the status of non-combatant/prisoner-of-war (PoW). Another example of this would be serrated-edged bayonets or blades, those that have saw blades or barbs, as the wounds created by such an edge are incredibly difficult to heal if the victim were to survive an attack.

The First World War was also a catalyst in the movement to humane warfare, as this total war brought about the use of chemical gasses that were so prevalent in trench conflict saw millions of troops suffer horribly at the hands of such an indiscriminate weapon.[15] Those that would live after having been exposed to the weapon, such as 'mustard gas', would suffer debilitating chemical burns and remove any quality of life possible. This sparked the Geneva Protocol of 1925, and the more modern 1993 Chemical Weapons Convention, that seek to remove these means from the playing field. We explore the lifecycle and evolution of the respective chemical and biological conventions as a precursor to the Blinding Lasers Protocol, in Chapter 4. The Second World War brought in perhaps the most prominent and notable of all IHL legislative pieces, the Geneva Conventions and their successive Additional Protocols, which redefined the

[14] Hague Regulations 1907, Geneva Conventions 1949 and Additional Protocols 1977.

[15] Y. Sandoz, *Convention of 10 October 1980 on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects* (United Nations Audiovisual Library of International Law 2010) pp. 1-5

20th century stance on the rights of those affected by international conflict. Those that were wounded by battle, the ways in which they could be legally wounded and civilians not party to the conflict were at the forefront of such design. Historically, the way in which IHL is derived has, sadly, been responsive rather than one that looks to prohibit a weapon before it has established its unsavoury reputation. The International Committee of the Red Cross (ICRC) does acknowledge this, with the difficulty of applying pre-existing law to future technologies an ambitious goal when the foreseeable humanitarian impact is not always clear. This will be explored further in Chapter 4, where these crucial pieces of legislation will be used as an example for the necessity of lawmakers to consider future eventualities rather than relying on their occurrence to draft prohibitions. Therefore, if predictive legislation can anticipate the effects of laser weapons before they become a conventional weapon, their design and uses may be more effectively restricted so that they may perform their military purpose without controversy. Preventing an illegal weapon from being mass-manufactured in the first instance would not only dissuade more law-abiding countries from experimenting with it, but also preventing it from falling into the hands of lawless non-State actors.

Further in an effort to predict the future of conflict, the International Institute of Humanitarian Law (IIHL) produced a text in 2011 that hoped to combine the knowledge and military expertise from all corners of the world. Despite the focus primarily on cyber warfare, a unique form of conflict where the battles are fought on an intangible domain yet heavily impact the physical world, there was dialogue on energy weapons. As technology advances, we may regard the move away from physical 'boots on the ground' combat to be a positive result for IHL, as it surely means less combatants in harm's way. Nevertheless, as the IIHL states in their concluding remark in their examination:[16]

> *"…so new technologies, however protective for the troops, will always have to be tested for their compatibility with humanitarian law and in particular their possible indiscriminate or disproportionate effects."*

We must apply this same philosophy to the idea of laser weapons as we examine each element. Laser weapons, in their development, may require less physical combatant presence on the battlefield if there are more suitable alternatives open as a result of their deployment. If upon

[16] P. Spoerri, *Concluding Remarks* (34th Round Table on Current Issues of International Humanitarian Law, International Humanitarian Law and New Weapon Technologies, Vol.94(866) 2011) pp. 815-817

their deployment, however, they were to leave scarring thermal wounds on their intended targets with no certainty of a quick death, this would be a cause for concern under the principles we have already reflected on. This will be explored to a greater extent in the final part of this Thesis, as comparisons will be drawn to what laser weapons could take the form of regarding already existing prohibitions in IHL, such as incendiary weapons. Now that we have covered the more general move to humane warfare in the context of superfluous injury, we can begin to develop the idea of military necessity in the normative sense. Superfluous injury will also be the backdrop of Chapter 4, where pro-active law-making was able to prevent humanitarian issues from arising out of one particular form of laser-based combat (or consequence thereof).

3.2 Military Necessity, Targeting and Discriminate Weaponry

When considering *Jus in Bello* or, alternatively, the laws that hold jurisdiction over military acts once a war has technically begun, the concepts of both military necessity and discrimination play a vital role. Whilst civilian objects are almost always prohibited to target, the lines become blurred in instances where they provide both civilian function and military purpose. This could cause conflict with Article 48 of Protocol 1, which demands the distinction between civilian population and active combatants. For example, a field hospital that provides aid relief to combatants and civilians alike could present itself as a military target, however it would breach many customary laws of IHL were it to be targeted. Recently, an Israeli strike on an Al Jazeera broadcasting station in the Gaza strip was justified by claiming the civilian building contained Hamas military assets.[17] Israel have been condemned over their supposed indiscriminate attacks during their conflict with Palestine, this being one of them which was heavily denounced. In this way, bombing runs and missile strikes can prove tough to isolate the damage caused, resulting in an indiscriminate weapon. The more indiscriminate the tactic deployed by a military; the more civilian casualties are likely to occur as a collateral effect. This section seeks to explore the roots of military necessity within conflict and how laser weaponry and targeting tools can provide a solution to the requirement of discriminate attacks. Whilst weapons of the past, such as chemical warfare, have highlighted the epitome of reckless warfare, a weapon that can be targeted so accurately and precisely as that of a laser could destroy legitimate targets with no fear of unwarranted destruction. The real debate will be as to how easily this method can be implemented or, more realistically, whether there would be a desire from less official parties to welcome the high cost of evolutionary weapons.

Let us first consider how we may define military necessity, or hold it to certain criteria when applying practical tests. The ICRC summarises military necessity as acts which are necessary

[17] Al Jazeera, ‘Silence the story’: Israeli bombing of media offices condemned, 15 May 2021 (Al Jazeera media outlet)

to accomplish a legitimate military purpose, which would be to weaken the military capacity of the other parties to the conflict. This would run side-by-side with the principle of proportionality, where any undesired but necessary collateral loss should be weighed against the benefits of committing to a certain act. This will be explored greater in the following section, which will also introduce a more philosophical insight as to accomplishing the greater good. Hayashi highlights the difference in thinking between material and normative military necessity.[18] The strategic commander may judge what is necessary through his resources, or lack thereof, in order to win the battle. This is one form of necessity, which could also encapsulate the old saying of *'exitus acta probat'* (the ends justify the means). Whilst this commander may be effective, we are concerned with the commander who considers the legitimacy of his acts before executing them, effective or otherwise.

At the time of writing this essay, the Russian Federation's invasion of Ukraine has taken centre stage as the world hinges on the survival of democracy in Eastern Europe. Although tragic in its nature and senseless in the loss of life that has been witnessed, it serves as an excellent contrast between legitimate targeting and indiscriminate methods of warfare. For the aforementioned hypothetical commanders, we can substitute these with the likes of President Zelensky and President Putin, as each have embodied two different manifestations of military necessity. In targeting the Russian forces that have moved into Ukrainian territory, one of Zelensky's greatest assets has been the Bayraktar TB2 Turkish drone, capable of missile strikes that are both precise and devastating. These drones are the same asset that allowed Azerbaijan to produce tactical results in Armenian-occupied areas.[19] This has been an invaluable tool in destroying columns of Russian armour that have moved in from the East, one that comes at no risk of Ukrainian casualty due to being a UAV (unmanned air vehicle). The projectile launched from the TB2 is a laser-guided bomb, utilising the infrared spectrum to guide the MAM (Smart Micro Munition) accurately to its target. The explosion radius of the MAM can be significant, leaving large craters in the ground and the chance of unwanted collateral damage. In the flashpoint of the Ukraine crisis, this has proved useful as the Russian convoys have stayed close and compact, rather than spread out, meaning the missile strikes were able to destroy many legitimate targets at once. So far, there is no evidence to suggest that the TB2 has been utilised in contravention of the LOAC, purely for the defence of the nation in effectively halting the progress of heavy Russian armour. An additional anti-armour tool that has been equipped by the Ukrainian ground forces is that of the Stugna-P, which requires a continuous targeting laser to be directed at the target. These mobile artillery tripods come complete with a thermal display,

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[18] N. Hayashi, *Requirements of Military Necessity in International Humanitarian Law and International Criminal Law* (Boston University International Law Journal, Vol.28 No.1 2010) pp. 41-56

[19] F. Shahbaz, *Tactical Reasons Behind Military Breakthrough in Karabakh Conflict* (Jamestown Foundation, Eurasia Daily Monitor, Vol.17(155) 2020) pp.155-157

where the laser itself can be assuredly maintained on a visible target. The Russian anti-laser system Shtora-1, an electro-optical 'shield' designed to disrupt targeting and range-finding lasers, hoped to combat these threats. Combat footage already documented of the conflict shows that this can be easily penetrated by those operating the Stugna-P, simply by aiming the laser above the shielded target until after launch, where it can then be re-acquired without ample time for the Shtora-1 to react. Both the Bayraktar drone and anti-armour equipment discriminate effectively due to their laser-operated systems and incredible accuracy. This is a 'commander' who has found an implementation of military necessity that adheres to wider principles outside of pure strategy.

Figure 2 – A Bayraktar TB2 Drone used in the defence of Ukraine

The approach of the Russian Federation, and of our opposing commander, has proved to be slightly more indiscriminate in their means.[20] Naturally, as the invading force, it is of no surprise that more offensive methods would be undertaken. Unlike previous comparable conflicts, we live in an age of both information and misinformation, a war both on the ground and through the media that is digested by either party to the conflict. This has allowed the world access to real-time updates, photos and videos of the actions taken by both sides. One thing that would be hard to dispute, however, is the unlawful and indiscriminate targeting of civilian infrastructure in attempts to hold key areas of Ukraine. This has come from alleged reports of cluster munition tactics, an effective weapon for widespread damage although near impossible

[20] Noted that this conflict is still ongoing, where many war crimes have only been reported and not formally confirmed. There should be more concrete reflection upon the termination of hostilities, which I do not yet have the privilege of witnessing.

to direct at singular targets. Thermobaric weapons have also been confirmed as a tool of the Russian offensive, specifically the TOS-1A rocket launchers which cause explosions far deadlier than conventional artillery. As the projectile explodes, it scatters fuel into the air around it, which is then ignited by a secondary charge, creating a large fireball capable of enormous destructive power.[21] Perhaps the most flagrant disregard for international law came with the destruction of a maternity hospital in Mariupol, resulting in the death of three civilians and injured many more.[22] As ground is recaptured by Ukrainian forces, even more evidence of potential war crimes are being discovered in the wake of Russian aftermath. As we can see from these examples, there appears to be little regard for international law from the invading forces, rather an effort to cause as much destruction as possible and displace the civilian population in doing so.

These ideas of military necessity through targeting legitimate objects will be crucial to our understanding of laser weapons further into this essay as we look to the potential of harnessing DEWs. If a UAV, much like the Bayraktar TB2 drone, were equipped with powerful optical lasers that were capable of incapacitating heavy armour it could solve many of the collateral issues they currently present. For example, a Russian convoy moving through the civilian streets of Kyiv would force the operator of a drone to weigh the pros and cons of their actions before launching the MAM. Whilst it would no doubt be a legitimate target, it could have a seriously adverse effect on the civilian infrastructure and their inhabitants. This is the idea of proportionality which will be explored shortly, where outcome is used to judge or justify acts, rather than the act itself. A fine optical laser that could be traced to within a cm or two of its intended target could render heavy armour completely useless, whilst avoiding the repercussions of a blast radius. It could also prevent combatant deaths where they were not necessary, if an opposing force relied solely upon their equipment. Indeed, it may not even be a fit weapon for direct combatant usage, much like the blinding lasers that will be discussed in Chapter 4. Where a singular beam of energy would prove effective against larger targets, it could go against our previously mentioned ideas of superfluous injury and unnecessary suffering were it to come into contact with the human body. It could prove non-fatal in its deliverance, causing amputations and scars that would leave quality of life at a minimum. In this way, it is important to understand the risks new weaponry may pose as well as its benefits, also further explored in Chapter 4 which looks to the pro-active nature of the Convention. DEW technology would also need this same foresight, with its use on the battlefield strictly endorsed for targets that would not be appropriate in the eyes of military necessity.

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[21] T. Baskin & J. Holcomb, *Bombs, Mines, Blast, Fragmentation, and Thermobaric Mechanisms of Injury* (Ballistic Trauma, Springer 2005) pp. 47-54

[22] BBC News "Three dead as maternity hospital hit by Russian Airstrike", 10th March 2022 (Report)

3.3 Proportionality and Justification

> *"The end may justify the means as long as there is something that justifies the end." – Leon Trotsky*

As discussed, the ideas of proportionality can be intertwined with the principle of military necessity. Whilst it is only considered acceptable to follow ends that seek to neutralise legitimate military targets, this may not always be a clear cut decision. An action that may bring peace through violent methods may be considered appropriately proportional if it prevents a pro-longed event of lasting violence, even if this violence would not see acts as unsavoury as those that were undertaken in its prevention. Ultimately, this section will discuss both the legal and utilitarian perspective on adopting means that are considered criminal when in the realm of international law.

Perhaps the greatest and most relevant example of proportionality would be the first (and hopefully only) time a nuclear weapon was deployed against another State. In August 1945, the United States deployed atomic bombs over the cities of Hiroshima and Nagasaki in Japan, killing hundreds of thousands of civilians and bringing a swift end to the Second World War. By today's standards, this act would have no greater in terms of defiling international law as to the indiscriminate targeting of civilians and loss of life that it brought about. Retrospectively, almost 20 years after the atomic flashpoint, the case of *Ryuichi Shimoda et al. v. The State* was successful in its attempt at labelling the bombings as an illegal act under international law. As the Geneva Conventions did not exist at the time of the bombings, several areas of the Hague Convention of 1907 were used to prove the United States' unlawful tactics. Most notably, Parts IV and IX,[23] where it was concluded that this constituted blind aerial bombardment of a city that was so remote to the war it could not be considered one that was 'defended'. Although the courts did uphold the nature of military necessity and how the destruction of non-military assets can be found to be lawful in certain instances, the very nature of the weapons deployed here shifted proportionality away from such lawfulness:[24]

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[23] '*The Laws and Customs of War on Land'* and *'Bombardment by Naval Forces in Time of War'* respectively.

[24] R. Falk, *The Shimoda Case: A Legal Appraisal of the Atomic Attacks upon Hiroshima and Nagasaki* (The American Journal of International Law Vol.59 No.4 1965) pp. 765-782

> *"It must be regarded as indiscriminate aerial bombardment of undefended cities, even if it were directed at military objectives only, inasmuch as it resulted in damage comparable to that caused by indiscriminate bombardment"*

Just as we have explored the targeting of military structures versus civilian occupancies, the proportionality of military gain from these acts were obviously overshadowed by the tremendous loss of life it caused on a grander scale.

If we were to move away from the legal perspective of proportionality, however, and look more to whether the nuclear action was justifiable in the grander scheme of things, we may find a different answer. The Peace Memorial Ceremony that is held in Hiroshima every year looks back on those who lost their lives and families in the two bombings, whilst also reflecting on lasting world peace. Whilst the atomic detonations are by no means celebrated, with Japan hosting a famous anti-nuclear sentiment, it is understood that the life lost in the nuclear war prevented an escalation to the Second World War. It would have been inevitable that, given Japan's unwillingness to surrender after the fall of Nazi Germany, that mainland Japan would have witnessed boots-on-the-ground conflict as many other parts of the world had been burdened with in the previous years. Indeed, the risk of Japan being entirely annexed by Russia, if not segmented as Berlin was, would have been a terrible prospect for the years to come and for national identity. From this viewpoint, moving from the legal to the philosophical, one could view this area of international law from a utilitarian and consequentialist perspective. This is concerned with the outcome of actions and, in short, the greatest good they can provide for the greatest number of people. If we were to take Bentham's hedonic calculus and apply it to our nuclear scenario, it may certainly fail the intensity test but would perhaps be offset by the duration. Though this military tactic was the epitome of indiscriminate warfare, it is important to see that some acts, though considered barbaric and unjust, may bring about an outcome more peaceful seen only through the privilege of hindsight.

4 Blinding Lasers and Protocol IV to the 1980 Convention on Certain Conventional Weapons

The greatest piece of international legislation that sought to restrict light as a weapon came about to prohibit permanent loss of sight as a result of the deployment of lasers on the battlefield, with the principles of superfluous and unnecessary suffering underpinning the Protocol. This came about in Vienna in 1995 as part of an official review of the Convention to update its scope with newer forms of technology. The full name given to the restrictive legislation was Protocol IV of the 1980 Convention on Certain Conventional Weapons. Further to my statement above, regarding IHL being mostly re-active rather than pro-active, this was the first time since the St Petersburg Declaration of 1868 that a weapon was prohibited before its affects were widely felt on the battlefield. As the first piece of legislation that dealt with lasers during wartime, it was a monumental statute in that it successfully utilised humanitarian foresight into a medium of weapon that was still relatively untested.[25] Arguments put forward that attempted to claim that permanent blindness was more humane an option than death failed, as States understood it to be equivalent to a death sentence regardless, simply a more painful one.[26]

In this Chapter, I will attempt to put forward scholarly opinions on this legislation that both praise its effectiveness in anticipating this threat whilst also presenting arguments that may say it does not go far enough in its prohibition. Before looking at Protocol IV, I will first explore other legislative pieces that were only able to react rather than predict and prohibit effectively. Looking at the how the Blind Lasers Protocol is worded will be important, not just in assessing how it can be interpreted, but also as it will form the basis of this Thesis' loose recommendation for laser weapons in our final Chapter.

4.1 Reactive and Proactive Legislation within IHL

Not only was this the first time since the St Petersburg Declaration that a specific weapon was prohibited before widescale adoption, it was the first time a weapon's transfer was also banned.[27] In this section, I will look to prove the effectiveness of our Protocol IV in creating a pro-active ban by comparing it to examples where, whilst there was some foresight, terrible

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[25] B. Carnahan & M. Robertson, "*The Protocol on "Blinding Laser Weapons": A New Direction for International Humanitarian Law* (American Journal of International Law, Vol.90(3) 1996) pp. 484-490

[26] S. Casey-Maslen, *Kinetic and non-kinetic energy weapons: a marriage made in heaven?* (34th Round Table on Current Issues of International Humanitarian Law, International Humanitarian Law and New Weapon Technologies, 2011) pp.83-86

[27] A. Peters, *Blinding Laser Weapons: New Limits on the Technology of Warfare* (Loyola L.A. Vol.18 No.4 733 1996) pp. 735

events were needed to be felt before its restriction truly evolved to where we have it in the present day. I will mainly focus on the emergence of chemical and biological weapons as an example, before we return to our laser-based theme.

The events of the 20th Century that the world bore witness to resulted in some of the most important legislation to try and prevent its reoccurrence. The First World War was particularly brutal, with tactics deployed by all sides during the fierce trench warfare that ensued across Europe. We have already touched upon the use of 'mustard gas' in this war, that would slowly compromise its victims and the slow death that would come about as a result. This was a tool of trench warfare along with many other similar agents, culminating in an estimated 1.3 million casualties from this cause alone.[28] Ironically, the Hague Conventions of both 1899 and 1907 did attempt to nullify the adverse effects the First World War would bring, almost as though the powers behind the Declarations knew of the impending war. Declaration IV, 2; concerning Asphyxiating Poisonous Gases from the 1899 Convention was particular topical:

"This declaration states that, in any war between signatory powers, the parties will abstain from using projectiles "the sole object of which is the diffusion of asphyxiating or deleterious gases"

As we have already explored, this exact use of a gaseous compound would have been a severe breach of this particular Declaration, despite being ratified by all but one of the signatories. Although there was clearly intention here to prevent unnecessary suffering on the battlefields to come, where there has been a clear determination for pro-activity, it was not until the 1925 Geneva Protocol that this intention was taken with its purported severity. The following specifically banned all biological and chemical warfare elements:

"Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned…the prohibition of such use has been declared in Treaties…and To the end that this prohibition shall be universally accepted as a part of International Law"

In this way, we must ask why the original attempt to prohibit such weapons failed. Did a horrific flashpoint need to occur for the court of public opinion to hold enough sway as to future legislation? Or perhaps the particular Declaration was lost in amongst a greater Conference that was more concerned with the outbreak of war itself along with hidden agendas. Certainly, there did not need to be a particular event for Protocol IV on Blinding Lasers to come to fruition, although admittedly this was in a time when IHL was taken far more seriously. Although it

[28] (from this figure, almost 100,000 deaths)

would be easy to write the Hague Conventions off due to the conflict it failed to control, they may have succeeded in creating the building block for future expansion of legislation. Indeed, the Biological Weapons Convention 1972 was a step towards removing the truly grave threat of Weapons of Mass Destruction (WMDs), with only a few notable non-signatories in the African continent.[29] The Geneva Convention of 1925 was confirmed to have been breached by major State actors, throughout the Second World War and Cold War hostilities. One conflict that brought about contentious post-war legal action and scrutiny was the use of Agent Orange by US forces against the Vietnamese, both destructive on a human and environmental level. Whist technically a herbicide, with its supposed intention for the destruction of jungle and foliage only, it strayed into the grey area of international law with debate as to its status as a war crime still very much undecided. The adverse long-term consequences it has proven to have had on the millions of people who were exposed to it, does have significant empirical standing. Perhaps the most notable and memorable conflict that saw the most heinous breach of this customary IHL was that of the Iran-Iraq war from 1980-88, which saw the indiscriminate use of nerve gasses against both Iranian combatants and civilians.[30] The reaction of the international community was, once again, to bolster the resistance to this military tactic having witnessed yet another flashpoint of its use. This ultimately leads us to the Chemical Weapons Convention 1993, which has seen almost worldwide adoption and a near-total destruction of chemical weapon reserves.[31]

Ultimately, this historic preamble to the Blinding Lasers Protocol has hoped to show that despite similar instances of pro-active law-making, this may not be enough for total universal adoption. Perhaps this is due to the fact these methods of warfare were already designed and readily available, with no true consequence as to their use if the need arose. Regardless, we are in a state at present where, were a chemical attack to be launched by a State-actor, there may be enough of an egregious breach of customary international law for outside intervention. At the time of writing, supporting powers of Ukraine in their conflict with the Russian Federation have been firm in their stance of non-participation.[32] However, it was warned that were the invading forces to resort to chemical warfare, then this may trigger a grave enough war crime to warrant a combined and joint response from allied nations.[33] It would be fair to argue that

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[29] J. Goldblat, *The Biological Weapons Convention: An overview* (International Review of the Red Cross No. 318 1997) pp. 253-259

[30] D. Segal, *The Iran-Iraq War: A Military Analysis* (Foreign Affairs, New York, Vol.66(5) 946 1988) pp. 957-960

[31] Organisation for the Prohibition of Chemical Weapons, OPCW by the Numbers Destruction Progress (statistics)

[32] other than indirectly through aid and military equipment.

[33] BBC News, "Ukraine: NATO will respond if Russia uses chemical weapons, warns Biden", 25th March 2022 (Report)

we are only currently in a world where both biological and chemical weapons are taboo to this extent, due in part to the initial Hague Conventions at the turn of the 19th Century. They should still be praised for their pro-active attempt, even if it ultimately took a century for the world around them to adjust to the demands they intended to lay down.

4.2 Language and Wording of the Convention

The Protocol IV consists of four Articles, which are simply worded and look to concisely lay out their purpose. Each Article will be broken down into its intent and effect, with any relevant scholarly opinion provided in support or critique.

Article 1:
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. The High Contracting Parties shall not transfer such weapons to any State or non-State entity.

The first Article acts as our definition for what constitutes a blinding laser weapon under the prohibition. This is the greatest attempt at pro-actively stopping the research and development of a blinding laser weapon at its inception, with any weapon that is designed to cause this injury. The use of the term 'combat function' would look to the purpose of the weapon and how it is used rather than the damage it can cause in actuality, otherwise many of the targeting tools that are already widely available would be caught under too fell a sweep of this Article. A function that is pursued in of itself, in contrast to an unintended collateral function through a legitimately sought objective, is the true distinction we should highlight here.

Those that would be artificially and substantively exposing themselves to a greater intensity of light, through binoculars for example, are clearly not protected by the intention of this Protocol. If they were, this would allow military targets to purposefully deter their enemy from deploying laser-based tools due to the threat of committing a war crime where they may not intend it. This would practically make these tools indirectly unlawful, if the deploying State could not guarantee that no permanent blindness would come about as a result of its targeting. The same principle, although slightly more extreme in its essence, would be that of children who are forced to fight as combatants in a conflict. Outlawing the targeting of these 'combatants' may seem humane but would only serve as encouragement for those in leadership roles to exploit this means of warfare even further. Praying on a compliant State's conscience to avoid breaking international law is, in itself, a tactic that may deployed by those who care little for IHL, particularly non-State actors. This is a common tactic used by warlords in the African continent, such as Congo and Somalia, if not just to groom and desensitise future soldiers at a young age.

Most notably, in regard to international conflict, child soldiers were used in Afghanistan as suicide bombers due to the unwillingness of the occupying forces to target the youth.[34] With the same mindset, a permanent lookout could be stationed at every strategic point of interest with enhanced vision so as to taint any legitimate targeting of their territory with a criminal label. This would create a threat of superfluous injury which would otherwise be absent, so as to be contradictory to the very idea behind any competent legislation.

Some consideration should be given to the final part of this Article, which would prohibit any sort of profiteering from these weapons, regardless of whether their own military is equipped with them. A coherence can be formed here in regard to the *Nicaragua v. The United States of America (1986)* ICJ case, where supporting a non-State or third-party could amount to a breach of international law. In the same way with this provision, a signatory to this Protocol should not seek to circumvent its scope by providing prohibited equipment to other militaries. Not only does it look to prohibit direct use, but also cuts off the distribution network at its source to ensure such tools do not fall into the wrong hands. The incentive to create the tools, where there would be no legal way to either use or sell them, would be greatly diminished.

Article 2:
In the employment of laser systems, the High Contracting Parties shall take all feasible precautions to avoid the incidence of permanent blindness to unenhanced vision. Such precautions shall include training of their armed forces and other practical measures.

Perhaps the most important language used in our second Article, where no doubt the greatest room for interpretation will be found, is the use of 'feasible precautions'. What some may consider to be feasible when reading words in legislation may not reflect the same when in a combat situation where lives are at stake. Indeed, if there is room for preparation and consolidation before a targeted strike, one would be very much expected to ensure their targeting tools would not conflict with the Protocol. In other cases, where a small infantry unit must react quickly to enemy armour emerging through the treeline, I would suspect that the welfare of their enemies would not be a priority if at risk of heavy fire themselves. What is considered 'feasible' and 'practical' will therefore be heavily reliant on the context of the situation, where hindsight may not truly be able to reflect upon the emotions at the time. Although this Article is important, so as to ensure there is some forethought and professionalism in situations where they may be permitted, it does seem to favour the probability of contextual justification.

[34] I, Overton, "A short history of suicide bombing", Action on Armed Violence 23rd August 2020 (Report)

Article 3:
Blinding as an incidental or collateral effect of the legitimate military employment of laser systems, including laser systems used against optical equipment, is not covered by the prohibition of this Protocol.

As we will discuss in the last portion of Chapter 4, this Protocol is not absolute. Ultimately, it looks more to the purpose and initial deployment than the end result, with the mentality of the user operating the laser system. It unapologetically accepts that there is to be no sweeping ban on these tools as this would be far too great an ask, rather implores 'legitimate military employment'. One could argue that the Protocol has already defined this term in Article 2, as long as all 'precautions' are taken. This could also refer to the wider idea of 'military necessity' and ensuring the targets are not civilians or non-combatants themselves. Unlike its predeceasing Articles, we are not presented with the necessity of 'unenhanced vision' within Article 3. In this way, even laser systems which have the ability to permanently blind the naked eye, as long as it is not intended as their combat function, could hold legitimacy on the battlefront. One must question whether this would now leave scope for a loophole of our first Article, where justifications could be made for the strength of the beam hidden under the guise of a legitimate combat function. A beam of light could be designed to hold unnecessary strength (kW) so as to have no greater effect in designating targets but provide the ancillary use of blinding even those who would be subject to it without 'enhancement'.

Article 4:
For the purpose of this protocol "permanent blindness" means irreversible and uncorrectable loss of vision which is seriously disabling with no prospect of recovery. Serious disability is equivalent to visual acuity of less than 20/200 Snellen measured using both eyes.

The final Article makes it clear that temporary blindness, where there is no serious long-term effect of the deployment, is not covered by the scope of the Protocol. This is important to note as those that seek to temporarily stun and disorientate targets, such as 'dazzlers', would not be prohibited under this piece of law. The laser dazzler is a series of emitters designed for the incapacitation of humans and optical equipment (sensors) alike, depending on the spectrum of light that is chosen.[35] Although these may be handheld devices, they are commonly equipped to heavy armour as a support function, or a non-lethal counterpart to the main weapons. Within the broad range of dazzling lasers, the effects can last anywhere from a few seconds to 3 minutes, which would obviously not come into conflict with Article 4. In a way, the laser

[35] L. Svec, J. Beer and D. Freeman, *Directed Energy in the Military Environment*, Naval Surface Warfare Centre 2012, pp. 76-80

dazzler is a more sophisticated and less aggressive adaptation of the stun grenade,[36] although may not encompass clearance situations where a stun grenade would be effective. Where a stun grenade causes both intense but temporary blindness and deafness, a legal blinding laser seeks to only inflict the former. The dazzling laser also removes the risk of causing permanent hearing loss that a stun grenade would threaten its victim with, as they may reach almost 200dB when exploding.[37]

4.3 Conflict within IHL and Applying Utilitarian Theory

Perhaps the greatest challenge to the Convention is the balance it must find in attempting to restrict blinding laser weapons, whilst not removing the ability for militaries to discriminate. It has been argued that range-finders and target illuminators should also be completely banned due to their ability to blind living targets were they to be used recklessly, however I believe this would create far more problems than it would solve.[38] Granted, the irreparable damage done to the human eye by these range finding weapons is a grave consequence, however the importance of these tools in ensuring that greater collateral damage does not occur is even more vital. It would be impossible for this piece of legislation to exist in an absolute form without the inclusion of Article 3 as, for the most part, laser guided systems are deployed legitimately and for good cause. Were this Protocol to propose a blanket ban for all laser tools with the capability of causing permanent blindness, no matter their intended purpose or necessity, it would have rendered army logistics to the equivalent of those in the mid-20th century. With such a dependence on targeting lasers, artillery and guided munitions would have fallen far more indiscriminately. In the age of urban warfare, where genuine military targets may be mere metres from a civilian building, this could prove detrimental to upholding these international principles at the disproportionate protection of protecting the few who may have been blinded by such equipment.

This would be another perfect example of applying the more philosophical approach of Utilitarianism to an otherwise strictly legal principle. Brandt draws distinctions in his writings as to the varying moral pillars that Utilitarianism may rest upon, notably when it comes to the rules of war. He references a form of ‘absolutism’, at the greatest end of one scale of the Utilitarian scale, where certain actions are morally always out of bounds and indefensible. Decisions such as executing a PoW, directly targeting civilians and torture for any purpose may all reflect this stance for a rule-utilitarian. Even in the application of absolute moral standards,

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[36] Also referred to as a ‘flashbang’, as to the two sensory receptors it looks to impair.

[37] C. Byers, *The Development of Blast-Actuated Impact Munitions* (Phoenix AZ 1998) pp. 6-10

[38] J. Marshall, *Blinding laser weapons: still available on the battlefield* (British Medical Journal, Vol.315(7120) 1997) pp. 1392-1394

where immediate expediency would bring a tactical advantage, one must not stray from them so their longevity is not compromised.[39] In the ideal world of the altruist, the universal application and practice of these principles would ultimately create the greatest overall good, or indeed happiness, over a sustained period of time. Whilst this is an admirable stance, in placing altruism above all, it may seek to disregard the consequences that strictly adhering to these principles may create. A rule-utilitarian, of the strict variety, would no doubt be of the critics of the Protocol on Blinding Lasers in its lack of absolution. Whilst this may completely remove such superfluous injury from the battlefield, I feel it would cause an imbalance among other areas of IHL already discussed. It also falsely assumed that all States, or Parties to warfare, would share the same willingness in adherence. If one State were to sacrifice its military advantage, say by refraining from torturing a PoW where its enemy would not do the same, there may be little incentive to continue this practice in the name of a higher purpose. Regardless, Article 5 of the United Nations Declaration of Human Rights 1987 provides the legal ramifications were this to be proven, as well as the Convention against Torture 1984.[40] There is no room for interpretation in these pieces of legislation, unlike the Protocol on Blinding Lasers, where Article 2.2 of the Convention against Torture summarises:

"No exceptional circumstances whatsoever, whether a state of war or a threat of war, internal political instability or any other public emergency, may be invoked as a justification of torture."

On the opposite wing of the horseshoe of utility, act-utilitarianism serves to look at the product of an action rather than the intrinsic morality on its application. The aforementioned Hedonic Calculus would form part of this variation to the overall theme, with the possibility of justifying acts its universal counter-part would adamantly prohibit. Where this Thesis may have already provided the impression that Utilitarianism places mankind at the centre of its priorities, this may falter on acts on a smaller scale. If we continue with our forbidden act of torture, both on a domestic and international scale, we can analyse how a military force organised purely on the theocracy of Act Utilitarianism may commit terrible deeds in order to achieve their greatest good. To those that look to the rules, where the means must justify the ends, one who looks to the ends first may accept a means which would otherwise be considered 'evil' in the name of a greater cause. Let us imagine a conflict where an end-of-world scenario is a true possibility, perhaps by way of nuclear armageddon. The losing Party has all but failed in their war efforts and have no resources left to continue the draining conflict, opting instead to decimate its opponent through M.A.D. Civilians and combatants alike are radicalised to the point of

[39] R. Brandt, *Utilitarianism and the Rules of War* (Philosophy and Public Affairs Vol.1(2) 1972) pp. 147

[40] … and Other Cruel, Inhuman or Degrading Treatment or Punishment.

extremism for this cause and a captured scientist refuses to reveal the location of the nuclear site that will launch the last desperate attempt to save face. Torturing this scientist may be the only way to expunge the coordinates of the site, which would be a grave breach of all concerning Conventions and IHL. Once again we are brought back to the concept of proportionality. At what point would an unthinkable act be acceptable in the wider scheme of the 'greater happiness', or indeed the fate of the planet? Are we able to sacrifice the principles we have so strictly adopted due to the convenience of the time? Now, the flashpoint I have presented is potentially the most severe, where few would look back to criticise the means due to the consequences it would avoid. Even the most resolute Rule Utilitarian would be forgiven for casting a blind eye, in breaking with their mantra. If we were to shift our example to that of the application of range-finders and laser-designators, encompassed by our Protocol on Blinding Lasers, we would be left with a less straightforward conclusion. The Protocol makes it clear that it does not cover collateral damage where 'feasible precautions' have been taken, through a device that does not have the combat function or objective to blind. We have already discussed how this still leaves the possibility of causing permanent blindness, through which we may draw a parallel with the playbook of the Rule Utilitarian. I would make the assumption a Rule Utilitarian would lay down an absolute moral law of, with universal longevity, never causing this superfluous injury on the battlefield. Even if these laser tools help support other humanitarian principles during a conflict, a world absent of blindness would be one to strive towards.

From what we have discussed above, I make the assertion that the LOAC itself attempts to act as a mediator between both ends of the Utilitarian Theory. Where some acts are (almost) wholly condemned as inexcusable, others may find their justification in the proportionality of the outcome. The Protocol on Blinding Lasers is no different, whilst it does ensure there is no malicious intent behind its deployment it does not unduly punish for unforeseen or unavoidable injury.

5 Experimental Laser Technology and Direct Energy Weapons

In the course of this exploration, we have discussed what has and is occurring on the battlefield when deploying laser technology. From the time of Archimedes, through the Petersburg Declaration, the innovation of the Cold War and modern warfare. In this way, the strengths and weaknesses of already existing laser weapons, whilst their coherence with the regulations set through international bodies, can be objectively assessed. In this final chapter, we move from the tangible to the theoretical, as we look to what the future will hold when the necessities of the battlefield demand evolution if victory is to be achievable. We will start by looking to the forms that lasers can take and the purposes they serve, whilst assessing the feasibility of moving from a targeting laser to one that could destroy military targets directly. Whilst the idea of a laser that could effortlessly cut through, ignite or otherwise render useless as its primary purpose is a provoking concept, there will be defences as to how it could be utilised to prevent unintended casualties. To do this, we may look to the current state of IHL to see how these weapons may slot in legally to an already existing framework. If their existence would be uncontested yet still potentially unstable, an idea of what future prohibitions we could expect will be discussed, as well as my personal recommendations for limiting them to uses which would be deemed uncontroversial.

5.1 A More Powerful Laser Weapon

At present, lasers are still primarily only employed as a range-finding and guidance too for ballistic weaponry. By its very purpose, this allows ballistics to find their target with greater accuracy and efficiency, ensuring they are discriminate rather than finalising their placement in an unintended location. We have already discussed how this assistive method of laser utilisation can be an effective tool for the battlefield, but when a laser shifts from tool to weapon it requires far more scrutiny. These lasers will form part of a larger group, previously referred to as Direct Energy Weapons. These are weapons that do not rely on projectiles and physical substance, rather the highly-focussed emittance of energy. At present, this genre of weaponry has taken a mostly defensive stance, used in anti-ballistic countermeasures where the speed of energy allows for a greater reaction time. However, the days of Archimedes' Solar Ray may be upon us again, only without the mythical debate of its existence.

The attempt at creating a laser that would be capable of destroying a target can be dated back to the last decade of the Cold War, however these were merely experimental and were all either deemed failures or cancelled. These include the US lead Project Excalibur which hoped to create an air defence system from a nuclear x-ray in the late 1970's, which met the same fate as

Reagan's SDI.[41] The Soviet's began research on a handheld laser weapon, not dissimilar to what was seen in the conventional sci-fi films that would have formed the cultural backdrop of the war. This too faded from any meaningful production as the USSR collapsed.[42] Modern day production has been far more successful in making high performance laser systems, partly due to being more realistic in their goals. There is no feasible way for a destructive laser to currently be isolated within a handheld device, the reaction chamber and energy required need a significant piece of machinery in order to handle such demand for kW output. Indeed, even partially successful projects such as the Tactical High Energy Laser (THEL) was cancelled in 2005 due to its poor mobility and extreme costs.[43] This deuterium fluoride laser, of the chemical variety, did exhibit a beam powerful enough to destroy artillery rockets and shells alike. However, due to its enormous size and demanding modular supports, it was never considered a feasible weapon for the battlefield. This would prove a similar conclusion to many of the weapon systems developed in the early 21st century, with the detriment of producing a quality beam creating too many physical and economical barriers to truly justify its ultimate adoption.[44]

The solution was to create a mobile laser system that could attach itself to either a large sea-faring vessel or truck. The AN/SEQ 3, for example, is a US designed 30 kW solid-state laser array that sits atop the USS Ponce, which is an amphibious naval transport vessel. This too was able to neutralise threats such as UAVs, artillery rounds and certain rockets at a far greater cost-effective benefit. Even small gun boats were proven susceptible to the 30kW beam, which could be one of the first examples of the laser being used in a combatant scenario. The Israeli counter-part to the AN/SEQ 3 is also a development to note, the 'Iron Beam'. This fibre-laser hopes to eventually replace Israel's famous 'Iron Dome' defence system, which has seen years of action during the ongoing Israel-Palestine conflict since 2011.[45] These air defence batteries are able to detect rockets and artillery shells to a distance of 70km, neutralising them only when their flight path is considered a threat. The counter-measure used is a 'Tapir' projectile, which is able to accurately find its target and create a flight path to intercept the offensive ballistics. The difficulty with replacing this system with a laser-based DEW, such as the AN/SEQ 3, is the lack of all-weather capability. Whilst the Iron Dome prides itself on functioning in all weather conditions, a laser has far more physical boundaries. A thick smoke screen, or even a particularly foggy day could nullify the effects of an optical laser weapon. Much like our

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[41] A. May, *Rockets and Ray Guns: The Sci-Fi Science of the Cold War* (Springer Cham, 1st ed., 2018) pp. 111-130

[42] A. Zak, "The Soviet Laser Space Pistol, Revealed", Popular Mechanics 14th June 2018 (Report)

[43] M. Lavan, *High Energy Laser Systems for Short Range Defense* (Acta Physica Polonica Series, Vol.115(6) 2009) pp. 960-965

[44] A. Lionis, *Experimental Design of a UCAV-Based High-Energy Weapon*, Naval Postgraduate School 2016, pp. 52

[45] M. Episkopos, "Is Israel's Iron Dome Enough to Protect It From Hamas?", The National Interest 13th May 2021 (Report)

analysis of Archimedes' Solar Ray, the beam itself must be sustained on the target in order to breach the surface or cause damage. By dispersing the beam in this manner, either as a pro-active countermeasure or a general weather condition, the replacement of a laser-based system of batteries is not appealing in comparison to the current 'Tapir' utilised system.

Figure 3 – The AN/SEQ-3 aboard the USS Ponce, able to mitigate threats from missiles, artillery and rockets.

With the above examples, the clash between laser systems and IHL is not particularly relevant, at least with optical lasers in their current state of development. As the defence systems only intend to, and are capable of, intercepting ballistic threats there is no resulting humanitarian aspect. It is when these lasers and other DEWs become capable of producing a beam powerful enough to move from a defensive tool to an offensive weapon that we must consider consequential effects. Although not discussed in great length during this Thesis topic, the move from conventional methods of boots-on -the-ground warfare to unmanned and distanced combat is already starting to become prevalent. Whilst we have already discussed the use of drone technology to launch precision strikes, autonomous weapons are also making themselves known. Whilst these weapons will have their own struggle with IHL in regard to targeting and differentiating from legitimate targets, I would be surprised if they did not eventually fully

utilise laser technology either as a targeting tool or as its mean of offensive weaponry.[46] The next section looks to these impacts of lethality and the use of DEWs on a global scale.

5.2 Other Forms of Direct Energy Weapon

Although this essay seeks to mainly address laser systems, there are other DEWs of note that will be necessary to address for our final recommendation on future restrictive Protocol. Whilst a laser may cause visible burning, blinding or deformation, other forms of energy may compromise the human body internally. It would be prudent to cover more than just the optical laser itself, as a DEW can take more than this form in its use. If we are to truly replicate pro-active legislation, on a part with the significance of the Blinding Laser Protocol, we must spare consideration to all forms that energy can manifest itself in when being used as a tool for the military. Where a laser is currently capable of blinding, where they may soon have more palpable effects on the body, other DEWs are capable of disturbing other internal systems. Whilst many of these potential weapons lie purely in their experimental phase, or indeed are only currently capable of destroying non-human targets, this is the perfect time to predict what they may become. These forms of energy that may be weaponised may not encompass all those that have the potential to leave their mark on the battlefield in the decades to come, simply they are those most known to us at this point in time.

A sonic weapon, which utilises sound to disrupt its targets, is a non-lethal crowd control device. These can be focussed or spread over an area, so as to disorient the target. Ranging from domestic devices, such as the ‘Mosquito’ in the United Kingdom, to the more offensive long-range acoustic device (LRAD).[47] Indeed, I can still remember walking past my local convenience store only to be greeted by an ultra-high pitched frequency that would encourage me to move on as fast as possible. Whilst these devices are, naturally, non-damaging to the recipient due to their widespread availability, the LRAD is a far more powerful sound-based device. They were originally designed in the early 21st Century in order for long range communication where it would otherwise prove difficult, however quickly developed into a more offensive tool. One area of interest is the disparity in non-lethal force that is permitted by domestic law enforcement against civilians and international law on the superfluous injury of combatants to an armed conflict. The LRAD, for example, has been utilised by police enforcement as a method of crown control and a dispersion tactic. The issue is that the beam of

[46] F. Sauer, *Lethal Autonomous Weapons Systems* (The Routledge Social Science Handbook of AI, 2021) pp. 237-245

[47] J. Schrantz, *The Long Range Acoustic Device: Don't Call It a Weapon - Them's Fightin' Words* (The Free Library, Army Lawyer 2010) pp. 4-10

sound an LRAD can generate can reach up to 160dB, which is delivered within the Hertz spectrum where human hearing can most easily receive it (up to 4,000). In this way, it can cause great discomfort to those who are subject to it, where damage can be caused to auditory vessels. Although this device is far from being weaponised, it does show the early signs similar to that of the blinding laser. It would be negligent to overlook a potential future where, after true military adoption, sound beams are indiscriminately used against combatants causing irreversible damage to their long-term hearing. Indeed, the US courts are currently in the process of analysing the legality of its use domestically, which could give rise to a justification for it to be embedded under international law. As this would constitute a DEW, much like an optical laser, we could compact this means of future warfare into our final theoretical exploration in the coming sub-Chapter.

We previously mentioned the SDI devised under the Reagan Administration, with its hope of conducting space warfare and dominance through the use or orbital lasers. This also hoped to encompass another form of energy-based weapon through the particle beam. Unlike optical lasers, which harness and refract light, the proposed particle beam or ion cannon seeks to directly disrupt the atomic and molecular structure of its target.[48] Ultimately, the charged atoms that a particle-based weapon creates exhibit tremendous kinetic energy that is then passed to its target, resulting in a similar heating consequence of a laser weapon but with far more an unstable and destructive outcome. In theory, this can be considered a weaponised particle accelerator, such as the Large Hadron Collider (LHC) which accelerates and collides highly-excited proton particles. With a collision of 13TeV (Teraelectronvolts), were these to be weaponised outside of laboratory conditions, it would have the ability to severely disrupt and break apart objects at a molecular level. Whilst these are fully functional and fundamental to the research of particle physics, a military particle beam would need to be able to operate outside of pre-defined containments within the atmosphere and would be subject to natural barriers such as blooming.[49] Furthermore, the LHC is also 17 miles in length, so to compact this into a portable military device is, at present and in the near-future, virtually impossible. Much like the struggles that occurred with optical laser R&D, where too many components and machinery were needed to create a weapon that was battlefield-efficient, the ambition of a particle accelerator for military use lies well beyond that of any high-powered laser. Similarly to the military advantages of an optical laser, a particle beam would naturally operate at the speed of light (or thereabouts), which would be crucial in aerial counter-measures for ballistics of all sizes. To successfully weaponize either of these forms of energy for standard deployment would severely disrupt the balance of the nuclear deterrent the world relies on, with the utilising nation

[48] B. Zohuri, *Directed-Energy Beam Weapons* (Springer Cham, 1st ed., 2019) pp. 136-146

[49] B. Zohuri, *Directed-Energy Weapons: Physics of High Energy Lasers* (Springer Cham, 1st ed., 2016) pp. 380-387

free to act unilaterally with no threat of effective retaliation. Even the hypersonic missiles may not be impervious to an automated response from these counter-measures, despite their ability to reach speeds greater than Mach 5.[50] Although this is less of an IHL issue, rather a global security consideration, if they were to be directed against targets rather than as a counter-measure it would surely require guidance for legitimate deployment. Regardless of its distant military future, to encompass particle beams within a theoretical Protocol on DEWs would be sensible, as a means of pro-active intention.

Our last deviation of energy lies on the electro-magnetic spectrum, with the ability to cause damage with microwave rays. Unsurprisingly, we are once again drawn to the development made in this area during the Cold War, particularly by the Soviet Union. This would become known as 'pulsed power', with incredibly high voltage and amperage (mV / kA), capable of producing a beam of energy with billions of wattage (gW).[51] Although speculation it was originally devised as a means of mind control, or psychological warfare, this purpose never came to fruition. These machines, such as the SINUS-6 generator, create brief but intense pulses of energy that would be extremely effective in disabling electronics without causing harm to biological matter. Depending on the level of gH used, this tool may be able to discriminate perfectly in a combat situation, disabling equipment and neutralising threats with no harm to the combatants using them. However, when focussed within a lower frequency, much like a sonic-based weapon, this results in the opposite. Known as the 'Frey Effect', which induces the perception of unusual and intangible audible noises in the mind after subjection to microwave radiation. This was the suspected cause of an illness that overcame US diplomats in Cuba and China from 2016 onwards, where no other purported cause was reasonable.[52] Brain injury, swelling, nausea-like symptoms as well as tinnitus were all prominent in the affected diplomats, with microwave radiation being the leading suspected cause. Were this weaponised form of radiation, with false perceptions and disillusions of sound, a real threat, this would have serious conflict with IHL. Not only would the aforementioned symptoms be considered superfluous, especially if brain-related injuries were not temporary, but the pulsed power generators would act indiscriminately without identifying legitimate combatant targets. Whilst a sonic weapon has the potential to cause great discomfort through the utilisation of sound, the ability to trick the mind into hearing false noises and compromise sanity could have even more severe consequences both in law and as a tactic for disrupting State personnel discreetly (even during peacetime). With this in mind, the idea of psychological warfare may not be such a stretch after

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[50] M. Finaud, *Hypersonic Missiles* (Initiatives pour le désarmement nucléaire, New Technologies and Nuclear Strategy, 2021) pp 6-12

[51] E. Schamiloglu, "Experts Believe US Embassies Were Hit With High-Power Microwaves – Here's How the Weapons Work", SciTechDaily 12th February 2022 (Article)

[52] B. Golomb, *Diplomats' Mystery Illness and Pulsed Radiofrequency/ Microwave Radiation* (Neural Comput Vol.30(11), 2018) pp. 2883-2898

all, although controlling the mind and bending its will may still be an implausibility left to Hollywood's imaginations.

5.3 My Recommendation for Future Laser and Energy Weapon Restrictions

For this part, I will look to combine the topics and principles we have already discussed to compose a formula that will allow us to create a hypothetical Convention that seeks to pro-actively restrict the use of optical laser and DEWs. The Chapters that have been visited, each with a different area of laser warfare, will lend itself to the establishment of the fictional closure I seek to end this Thesis with. For the purpose of this Sub-Chapter, it will be known as the 'Restrictions on Laser and Direct Energy Weapons (RoLDEW). This does not pretend to be a watertight piece of legislation, which would need careful craftsmanship and consideration to the weapons it would cover, rather a building block from which a true restrictive IHL Protocol may be formed. Within the RoLDEW, before we ascertain our guiding principles that will focus it on a humanitarian sense, let us define what is covered:

Definition of Restricted Weapons:
For the purposes of this Protocol, all devices that are primarily generated through the use of energy such as lasers, particle beams, microwaves and sonic-based weapons are covered by the Articles. The aforementioned list is non-exhaustive. These weapons will not exhibit ballistic or projectile attributes in their usage, though these traits may be a by-product of the initial sequence of energy and so should come into consideration in regard to collateral consequences.

For our Protocol, the focus should mainly be on targeting and what legitimate targets would look like. As previously mentioned, using a DEW against a combatant individually could create inhumane effects were it to produce a non-lethal outcome. Instead, DEWs and optical lasers will be better directed against military vehicles and targets where the combatant is not the primary focus. We can word this much like Article 2 from the Protocol on Blinding Laser Weapons. To take this preliminary Article further, I would recommend some discussion take place so as to replicate the actual Protocol on Blinding Lasers Article 1's approach in removing the ability to benefit from the design and research of illegitimate energy weapons, even if they are not to be employed by that State. This may prove more difficult due to the broader range of potential weapons that the RoLDEW would seek to have jurisdiction over. Implementing ideas of 'sole' or 'predominant' combat function could seek to limit these weapons, however with so many forms of energy weapon with the ability of harming different elements of the human body, it would need to be vaguely intertwined with superfluous injury. Although the length of this Thesis may not allow it, where this is but a foundation for a more competent piece of legislation, it would be more prudent to split the RoLDEW into separate Protocols for every

form of energy and their respective consequences. Regardless, I believe the above definition provides reasonable coverage for what is in scope.

Article 1:
In the employment of DEWs, all Contracting Parties should ensure that military armour and equipment is the primary target. The destruction and incapacitation of military assets is forefront to legitimate usage. Once legitimate targets are no longer functioning , they cease to become a military target for the purpose of this provision. Living military targets, namely combatants, should never be the focussed objective of a DEW.

Undoubtedly, contention will be held as to whether the target was the primary focus of the weapon, with secondary targets posing incorrectly as the main subject in order to bypass Article 1. If we were to release Article 1 with no supporting expansion, it would have little effect on the use of these weapons. In this way, much like our 'blinding' regulations, we will need to express that incidental and unnecessary suffering may not always be prohibited. If we are to take the most foreseeable injury from a laser, it would be deep-tissue scarring from burning or loss of limbs. Other DEWs, such as sound waves and microwave emitter, could have serious non-lethal consequences on the body as previously discussed, even if not visible by the naked eye. This would have a disproportionate effect as to the supposed benefit they would provide by inflicting casualties in a non-lethal manner. Other means of DEW, such as sound beams, would also be covered under these Articles, where predictable injury such as permanent deafness could occur.

Article 2:
Any damage done to combatants should be ancillary to its use and unavoidable, such as a pilot or driver of a military vehicle. In this way, DEWs should never be deployed solely for infantry combat where the non-lethal consequences could cause permanent debilitating injuries. Collateral damage of the legitimate deployment of DEWs is not covered by the prohibition of this Protocol.

With the combination of both Article 1 and 2, there should be enough limitations on DEW use to remove ill-conceived deployment on the battlefield. The key word here being '*unavoidable'*, which should be taken in its context of military necessity. An example where this would apply would be destruction of a tank where the driver was also exposed to the optical laser that cut through the hull. In doing so, the injuries he sustained were non-lethal but would require lifetime rehabilitation therapy. This would be the same as a blinding laser causing permanent sight loss to a combatant whose vision was enhanced through a tool. As long as the predominant purpose of the laser was not to blind, just as the purpose of our optical laser was to disable the armour, there would be no breach of Protocol. Much like our companion Protocol, it would be wise to

define the injuries that it seeks to prevent. For this, as it is more broad a term than blindness, we may need to both clarify the terms used as well as a more general and encompassing assessment on an individual's wellbeing.

Article 3:
For the purpose of this protocol, 'permanent debilitating injuries' refers to those that are sustained as a result of direct exposure to DEW deployment, where the damage inflicted physically or mentally, is enough to altogether diminish the general enjoyment of quality of life. These injuries are not repairable and would prevent simple day-to-day tasks from being carried out unassisted.

To give a workable example, let us say that two State Parties to a conflict are engaged with one another and border each other. The aggressor of the two States has begun to station its battalions within the larger cities near the border as it advances its troops onward to the capital. The occupied State launches several Bayraktar-like drones in an attempt to disrupt their enemy's advancement, however many of the occupying forces and now intermingled with civilian infrastructure. A laser-guided missile, such as the MAM, would pose a threat to the non-combatants who were unable to flee this invasion located in the surrounding buildings. Instead, these UAVs are equipped with a high-powered optical laser that is capable of navigating the gaps and alleyways between the apartment complexes. In doing so, it is able to incapacitate a great deal of enemy armour. The operator of these drones, paying good consideration to the above Articles, only directs his beam towards armoured vehicles and supplies as his absolute target. Once they have been rendered useless, they are no longer valid targets under this proposed Protocol so as to protect any survivors inside, so he moves to the next location. If these survivors are badly wounded, the operator would not be accountable for them under IHL. The combatants stationed around these armoured vehicles are not valid targets, so the operator ensures the beam of light does not pass near them if practically possible. No damage is caused to the civilian homes and the operator has avoided levelling an entire block of flats, that may or may not have been occupied.

With the above definition and subsequent three articles, I believe this would establish an effective foundation for the deployment of the weapons that future warfare will heavily revolve around. Of course, as with any event concerning military necessity, there will always be debate as to whether any consequential loss could have been avoided and whether it was proportional to the legitimate advantage gained. Regardless, it should be able to absolutely exclude situations where lasers would otherwise be used in the destruction of combatants with no military armour. Those that are not afforded protection under these Articles are those who are physically controlling the military armour, as they would constitute an unavoidable consequential loss of the legitimate use of the DEW. Of course, once the armour or legitimate target is non-

functioning, so too would the legal deployment of the weapon cease. One topic of debate I can already see as controversial would be targets such as APCs, which are designed to carry large numbers of combatants. Would it be proportional to deploy a DEW on this target? The chances of superfluous injury are strong with no guarantee of a quick death. Perhaps in these situations, amendments to the Protocol would need to be made so as to ensure every effort is made to target areas of the vehicle that are vital to its mobility, such as the engine. To expect warfare to be this disciplined, however, may be too great an ask.

6 Conclusion

This Thesis has sought to move from the early beginnings of bending light for military intent through to its modern utilisation. It has hoped to show both the ways in which it can be used as a tool to uphold international law, through its extremely efficient ability to discriminate, whilst also posing a challenge with the effect of causing permanent blindness and future considerations of effects to the body. Even if an optical laser is able to assist in one area of the LOAC, this may not justify the complications it can cause when utilised without proper forethought. It should also not be justified wrongly in the name of effectiveness, as we have looked to the application of proportionality and whether the ends can ever truly uphold questionable means. What is proportional may, in turn, play a crucial role in deciding what military necessity really means in situations where unwanted collateral damage is inevitable. Either by way of the target or the suffering the legitimate targets must endure. In assessing this, we have also touched upon the practicality of upholding international customs and that, as to the reality of the situation, not all actors are willing and/or able to conform.

Ultimately, the implication of this exploration would do well to highlight the need for pro-activity in regard to the future of lasers and energy weapons alike. Truly successful legislation is that which is able to predict rather than prevent a reoccurrence of. Future research and development should also be kept in mind, as this process will take the legality of the weapon they hope to create into account. This can be reflected in Article 1 of the Protocol on Blinding Lasers. Although many of the energy weapons that have been discussed may seem fictious at a stretch, it would be best to consider them at an early stage rather than waiting until their design has come to realisation.

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