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Nanotechnologically Enhanced Combat Systems: The Downside of Invulnerability

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Abstract: In this paper we argue that Nanotechnologically enhanced 'battle-suits' for soldiers will tend to exacerbate various ethical issues around asymmetric warfare between technologically advanced military superpowers and technologically disadvantaged military forces. Riskless warfare creates ethical problems that the superpower state must grapple with, in trying to determine whether and how it can justly engage in military conflicts involving profound military-technological disparities. But riskless warfare isn't an ethical problem from the point of view of the individual soldier in the superpower's military, insofar as that soldier's life remains under threat from opposing soldiers. The significance of enhanced battle-suit technology is that these risks to individual soldiers may become greatly mitigated, or even, in various cases, eliminated, which would in turn problematise the superpower soldier's justification for attacking the underdog soldier with lethal force, in a way that broadly resembles the 'paradox of riskless warfare' that applies at the level of the state.

1. Introduction

In the late 20th century and early 21st century to date, major military conflicts have increasingly been characterised by profound disparities between the armed forces of the belligerent parties. This is largely due to the decreased incidence of open hostilities between economically and technologically advanced states since the end of the Second World War. The point, simply, is that when advanced industrial states *do*

go to war nowadays, they tend not to go to war with each other. Instead, their opponents are typically either (i) economically less-developed states with relatively modest military capacities – as in the US-led 2003 invasion of Iraq, or the 2008 South Ossetia war between Russia and Georgia – or (ii) even more modestly equipped sub-state military insurgencies – as in the US-led post-2003 occupation of Iraq, or the US-led counter-insurgency operations in Afghanistan since 2002. In conflicts like these, the military forces of advanced industrial states hold a twofold advantage. On one hand they just have *more* war-fighting resources: soldiers, weapons, munitions, ships, planes, tanks, and communications/intelligence infrastructure. In addition, though, advanced industrial states also enjoy an advantage with respect to the technological capacities of the equipment at their disposal. To put it crudely, modern industrial superpowers don't just have more war-fighting resources than their less-developed military opponents, they have decidedly *better* resources as well.

A number of contemporary authors have argued that there are distinctive problems in the ethics of warfare which arise because of these 'military-technological divides' (Dunlap 1999, Kahn 2002, Boot 2006). According to these authors, profound disparities in war-fighting capabilities can make it especially difficult for warring parties – on either side of the divides – to pursue their military objectives in an ethically defensible manner. The emergence of nanotechnological applications in military contexts has the potential to exert considerable influence the nature of these military-technological divides (Altmann 2004, Shipbaugh 2006). Our aim in this paper, then, is to explore the ways in which nanotechnological developments may thus reshape the distinctive ethical problems to which these divides give rise.

Various nanotech applications might be examined with this end in mind. For instance, it could easily be assumed that the foremost candidate for our attention would be nanotechnological weapons of mass destructions (NTWMDs). However, we do not believe that the ethico-political challenges that would be raised by the advent of NTWMDs (and by the inevitable inequalities of access to NTWMDs) would be fundamentally different in kind from those the international community already faces in relation to thermonuclear weapons. Alternatively, there are several potentially revolutionary nanotechnological applications (e.g. those involving 'nano-dust' sensors, nano-scale robots, or genetically-targeted biological agents) whose realisation presumably *would* have novel and far-reaching implications in relation to the military-technological divides (see Altmann 2004). But these more revolutionary technologies may or may not materialise in the foreseeable future, and in any case we would still need to speculate extensively about the nature of their applications in order to say

anything specific about their ramifications for the ethics of warfare.¹ Instead, we will concentrate on a nanotechnological application which is already being developed and implemented in military contexts, namely, nanotechnologically enhanced battlesuits. The US military's primary development group for such battlesuits – the Institute for Soldier Nanotechnologies (ISN) – has as its stated aim to “exploit nanotechnology to dramatically increase the survivability of soldiers”.² We will argue here that technologies which enable the realisation of that goal would have a notable influence on the character of the military-technological divides and the moral problems to which they give rise. More contentiously, we will suggest that if such battlesuits became widely employed by military superpowers, this would increase the likelihood of modern wars being fought unjustly on both sides of the technological divide. The prospect of invulnerable or near-invulnerable soldiers may be desirable on the face of things, but there is a downside to invulnerability.

2. Just War Theory

Contemporary discourse on the ethics of warfare is commonly conducted within the moral framework provided by *just war theory* (JWT). We will be following suit for the purposes of this essay, to the extent that our discussion will proceed under the two assumptions which together constitute the core of the just war theoretical tradition. Those assumptions are: firstly, that under particular circumstances states or state-like actors can be justified in resorting to war, and secondly, that once states or state-like actors do resort to war, warfare can be carried out in a just manner. In making these assumptions we are rejecting, for the purposes of this essay, two competing traditions in the discourse warfare ethics, namely *political pacifism* (roughly, the view that states are never justified in resorting to war) and *political realism* (roughly, the view that the resort to war and the conduct of warfare are not amenable to ethical evaluation, and hence that they can neither be deemed just nor unjust). However, although we will hereafter be disregarding these alternatives to the JWT tradition, we do not thereby mean to generally endorse JWT against the rival pacifist and realist traditions. Rather, we are adopting a JWT framework for practical reasons. Our brief is to investigate the

¹ Our suggestion here is simply that we are not presently in a position to confidently predict whether and how certain far-off forms of nanotechnology will influence the military sphere. We acknowledge, though, that one may still be able to make an ethical case for the imposition of regulatory regimes or moratoria on the development of specific technologies, if one reasonably believes it is likely that those technologies will be very harmful. This is roughly the line that Jürgen Altmann takes in his analysis of potential nanotechnological military applications (Altmann 2004, Altmann and Gubrud 2004).

² Institute for Soldier Nanotechnologies, 2009 (see <http://web.mit.edu/isn>).

ethical implications of nanotechnological developments in relation to the ethics of warfare, but for political pacifists or political realists, nanotechnology – like any other kind of technology – simply has no ethical implications in relation to the ethics of warfare. Whatever nanotechnological developments may come, pacifists will still regard all war as unjust, and realists will still regard war as an element of political life that is outside the scope of moral judgement. It seems to us, then, that if there is anything interesting to say about the ethical ramifications of nanotechnology in the context of contemporary warfare, it will need to be articulated within a just war theoretic framework.

The two central claims/assumptions of the JWT tradition – that states can justly resort to war, and that wars can be carried out in a just manner – find their formal expression in two sets of normative principles, known in the JWT literature as the doctrines of *jus ad bellum* (justice in the resort to war) and *jus in bello* (justice in the conduct of war). On typical accounts, the doctrine of *jus ad bellum* stipulates six principles of justice in the resort to war, while the doctrine of *jus in bello* stipulates two principles of justice for the conduct of war (we summarise all eight of these principles in an appendix, §7). For the purposes of our arguments here, we are primarily concerned with the *jus in bello* principle of *discrimination*. According to this principle, conduct in warfare can be deemed just only if war-fighters discriminate between combatants and non-combatants, and do not target the latter.

3. Superpowers vs. Underdogs: Two Distinctive Ethical Problems

At this point it will be useful for us to introduce some simplifying terminology. We will use the term *superpower* to describe an economically and/or technologically advanced industrial state that has access to state of the art military technologies (e.g. weapons, munitions, vehicles) and para-military technologies (e.g. information technology or surveillance resources). Conversely, we will use the term *underdog* to describe a relatively less-developed state or a sub-state political group which has relatively modest military capacities in comparison to superpowers.

Expressed in this vocabulary, our suggestion from §1 was that when superpowers and underdogs oppose one another in military conflicts, certain distinctive ethical problems arise. To be clear, the suggestion here is not merely that wars between superpowers and underdogs are characteristically marred by injustice, either in their provenance or their execution. Whilst that claim is entirely plausible, the same could be said of wars between competing superpowers, or wars between competing underdogs, or wars involving states and political groups that do not sit comfortably in either camp. (One might make the same point in a different way by

simply stating that wars *generally* are marred by injustices.³) The claim that we are interested in, by contrast, is that there are distinctive reasons why injustices are likely to occur – and indeed frequently *do* occur – in military conflicts between underdogs and superpowers. We will focus on two problems of this type.

The Guerrilla Problem: This first problem arises due to the vast differences in the capacities of superpower forces and underdog forces to injure or kill opposing personnel. In conflicts between superpowers and underdogs, superpower war-fighters can locate, identify, and assault underdog personnel with relative ease and with a relatively low degree of risk to their own lives. Underdog war-fighters, on the other hand, often lack the capacities to effectively attack superpower forces if and when they're located; and even when the opportunity for a potentially lethal attack does present itself, underdog soldiers typically carry out such attacks at great risk to their own lives. In short, superpower soldiers are able to kill and/or maim underdog soldiers much more easily than underdog soldiers can kill or maim superpower soldiers. This kind of asymmetry gives rise to an ethical problem, because it typically occasions a resort to more pernicious war-fighting methodologies by underdog forces. In particular, this kind of asymmetry may drive underdog soldiers to inflict violence or the threat of violence upon individuals who *are* relatively susceptible to violent assault – i.e. non-combatants – with a view to leveraging the superpower into a disadvantageous course of action.⁴ To say that underdog war-fighters are *driven* to violate the principle of discrimination by attacking non-combatants is not to absolve underdogs of moral responsibility for those violations, nor is it to re-assign moral responsibility for such actions to superpower military forces. Rather, it is simply to acknowledge that the resort to pernicious war-fighting methods happens predictably, and for identifiable reasons. When an underdog is unable to resolve hostilities with a superpower via non-military methods, it is highly unlikely that the ensuing conflict will be carried out in mutual adherence to the principles of *jus in bello*; for if the underdog *did* adhere to those principles, it would almost certainly consign itself to defeat (and the further political, cultural, and economic consequences thereof) from

³ The claim that wars generally are marred by injustice may seem to imply a political pacifistic stance which is (by definition) incompatible with the tenets of the JWT tradition. But that need not be the case. The political pacifist claims that wars are unjust as a matter of necessity. The just war theorist, by contrast, says that wars can at least *in principle* be undertaken justly; whether or not wars typically *are* started and executed justly is a further (primarily empirical) question for the just war theorist.

⁴ As Dunlap (1999) notes, the threat or perpetration of violence by underdogs against non-combatants can assume a variety of forms. The most obvious examples would be direct assault (as in certain kinds of terrorist attacks), the use of human shields (either friendly or hostile), or the taking of hostages.

the outset. And so, if the underdog is unwilling to accept military domination, the use or threat of violence against non-combatants predictably follows.

We can briefly summarise the guerrilla problem as follows. Violations of the principles of *jus in bello* – specifically the principle of discrimination – are more likely to occur in military conflicts waged between superpowers and underdogs than in wars between forces with relatively similar capacities. This is because (i) underdogs in many cases are unwilling to acquiesce to the prospect of inevitable defeat and domination, and (ii) their best or only chance of avoiding this prospect is to resort to the use of violence or the threat of violence against non-combatants.

The Problem of Riskless Warfare: The second ethical problem also arises due to the vastly different degrees of ease and risk involved for superpower and underdog soldiers attempting to kill or maim their opponents. However, in order to get a grasp of this second problem we need to turn our attention to a foundational question in the ethics of warfare, namely: why it is that during wartime soldiers in general can justifiably be the targets of lethal violence (assuming with the just war theorist that this is indeed the case). The answer to this question clearly cannot be that soldiers in general are guilty of egregious wrongdoing such that they deserve to be killed or maimed. Nor can it be that soldiers in general unreservedly submit themselves to the risks that their profession entails, for we know that many soldiers are conscripted, and many more take up the vocation of out economic necessity. Rather than appealing to features or actions of individuals who take on the role of the soldier, then, it seems that the answer to this question must appeal to something about the war-fighting vocation itself. That is, in explaining why soldiers can justifiably be attacked and killed during warfare, we have to make reference to the distinctive capacities and abilities that individuals acquire in becoming soldiers, and also the ways in which those capacities have implications for other individuals (both combatants and non-combatants) in the context of war. A candidate account of this type would be to say that soldiers can be the target of lethal violence solely or primarily because *they too* have the capacity to visit lethal violence upon others. The just war theorist Michael Walzer posits such an explanation when he suggests that the war-fighter can be fought and attacked “only because he already is a fighter”.

He has been made into a dangerous man, and though his options may have been few, it is nevertheless accurate to say that he has allowed himself to be made into a dangerous man. For that reason, he finds himself endangered. (Walzer 2000, p. 145)

No doubt this account is in need of some refinement. For one thing, there are all sorts of dangerous men and women whom the just war theorist presumably *doesn't* want to deem liable to be killed on account of their dangerousness. What is needed, then, is some explanation of how the state of warfare itself, as a specific form of interaction between states or state-like actors, establishes a moral context in which the killing of 'dangerous' individuals (some of them, anyway) can be held apart from the political and ethical norms which otherwise govern life and death matters.⁵ Nevertheless, with these reservations noted, we concur with Walzer to the extent that we think the threat that soldiers pose in wartime – to other combatants and to non-combatants – must figure prominently in any account of why it is that soldiers in general can justifiably be attacked and killed. (Or, to make the same point in a more modest fashion, we think the onus is on the just war theorist who denies this claim to explain why soldiers can be targeted in a way that does *not* appeal to the soldier's capacity to pose a lethal threat to other combatants and to non-combatants.)

The problem of riskless warfare arises whenever underdog war-fighters have a drastically limited capacity – in comparison to superpower war-fighters – to pose a lethal threat to their opponents. If some part of the moral justification for soldiers attacking one another in wartime is (as we have suggested) that soldiers in general pose a potentially lethal threat to their military opponents, then underdog soldiers in many cases *cannot* be justifiably attacked by superpower soldiers. This is because under typical circumstances underdog soldiers plainly *do not* pose a credible threat to a superpower military force, given the profound disparities in their war-fighting capabilities. Ergo, to the extent that superpower war-fighters are required to attack underdog soldiers in war-fighting situations, superpower forces will be responsible for attacking and killing individuals without moral justification. The problem described

⁵ According to Walzer, the distinction between individuals who can justifiably be the targets of lethal violence in warfare and those who cannot should be drawn on the basis of whether the actions of the individuals in question are "threatening and harmful to their enemies" (p. 146). By engaging in threatening and harmful activities, Walzer argues, the individual relinquishes the rights in lieu of which he or she – like the rest of us – is normally immune from being the target of violence.

We do not think this can serve as a complete account of why soldiers (and other contributors to a state's armed forces) can be attacked in wartime. In short, we think that Walzer focuses too closely on individuals, and pays insufficient regard to the role that state institutions play in legitimising violence against members of their armed forces. If the soldier's activities are viewed in isolation from the belligerent intentions and war-fighting infrastructure of the state, they have a negligible capacity to be threatening or harmful other states. So whilst the 'dangerousness of the soldier' remains essential to an explanation of why the soldier can be targeted, it should be stressed that the kind of danger at issue is not merely interpersonal, but political; it is a danger *for* political communities (i.e. the danger of being dominated, subjugated to outsider rule), and it is a danger that can only be generated and sustained *by* political communities (i.e. by states, or by militant political groups aspiring to statehood).

here is essentially a re-working of an argument recently put forward by Paul Kahn. On Kahn's view, combatants in warfare are only justified in attacking one another "as long as they stand in a relationship of mutual risk" (2002, p. 3). But according to Kahn, an armed conflict in which one of the belligerent parties does not face any appreciable risk is not warfare at all, and as such the license for enemy soldiers to attack one another that exists during wartime (on a just war theoretic view) cannot be extended to soldiers engaged in profoundly asymmetrical conflicts (2002, p. 4). Although certain details of Kahn's account strike us as problematic⁶, we think the core elements of his view merit serious consideration. In accepting the *jus in bello* principle of discrimination, one must suppose that there is a meaningful distinction to be drawn between combatants and non-combatants. But any such distinction will prove altogether spurious if these categories are merely a matter of convention. So if some people are to be legitimately classified as combatants in the context of warfare – and if they are deemed liable to attack on that account – certain conditions must obtain, and one of those conditions surely must be the existence of interactions between the opposing parties which can be meaningfully characterised as a *combat*. When there are large disparities in the war-fighting capabilities of two opposing forces, the characterisation of their conflict as a combat comes under pressure. It does not seem implausible to suppose that an especially vast disparity in war-fighting capabilities could render such a characterisation positively farcical. But if that's right, then a superpower's justification for killing an underdog's opposing 'combatants' will obtain only to the extent that those fighters pose a credible threat to the superpower forces. Otherwise those individuals ought not to be seen as combatants at all, and they should be afforded the same presumptive (albeit still defeasible) immunity from violence that is afforded to non-combatants generally.

We can summarise the problem of riskless warfare as follows. Violations of the *jus in bello* principle of discrimination are more likely to occur in military conflicts waged between superpowers and underdogs than in wars between forces with relatively similar capacities. This is because (i) superpower soldiers will frequently be called upon to attack and kill underdog soldiers in such conflicts, and (ii) the classification of underdog soldiers as combatants – and the moral justification for superpower forces to attack underdog soldiers which depends upon that classification

⁶ In particular, we question Kahn's characterisation of morality on the battlefield as "a variation on the morality of individual self-defence" (p. 3). The kinds of cases in which violence for the purposes of self-defence seems unproblematic on a personal level are those in which the resort to violence is an unpremeditated response to a situation in which an individual's safety and/or survival comes under imminent threat. Insofar as the soldier's resort to violence is entirely premeditated (indeed, the resort to violence is inherent to the soldier's vocation) a very different kind of legitimising principle is needed.

– is rendered specious if and when underdog forces do not pose any credible threat to superpower forces (as is at least sometimes the case).

4. Nanotech Battlesuits

The question we now want to consider is whether and how the development of nanotechnologically enhanced battlesuits is likely to bear on the problems discussed in the preceding section. To do this we need an understanding of what functions and capacities these suits are expected to have, at least within the foreseeable future. For this we turn to the organisation responsible for carrying out the United States' research and development into battlesuits technologies – the Institute for Soldier Nanotechnologies (ISN). This MIT-based institute has been in operation since 2002, and as of 2009 it is in the middle stages of its second five-year contract with the US Army Research Office, the first of which was funded to the tune of US \$50M.⁷ The ISN is charged with the task of researching and developing nanotechnological applications which can be used to enhance the functional capacities of the next generation of soldier battlesuits. This research is animated by a bold vision:

Imagine a bullet-resistant jumpsuit, no thicker than ordinary spandex, that monitors health, eases injuries, communicates automatically, and reacts instantly to chemical and biological agents. It's a long-range vision for how fundamental nanoscience can make soldiers less vulnerable to enemy and environmental threats. (Institute for Soldier Nanotechnologies, 2009)

As this manifesto suggests, the battlesuit of the future will be more than just hi-tech body armour. The ISN's aim is to produce an integrated piece of equipment which combines a range of protective functions (protection against ballistics, explosives, electromagnetic radiation, chemical and biological agents) and medicative functions (monitoring of vital signs, the delivery of medicine), with various other more general functions of soldiering equipment and attire (communications, protection from the elements, camouflage) in order to maximise the efficiency and performance of all of these functions. Nanotechnological innovation is of central importance to this vision, insofar as it makes possible two key steps in the advancement and integration of the

⁷ See Institute of Soldier Nanotechnologies, 2009. Given that the US is currently the clear global leader in overall military spending, and in nanotechnological research funding, we think it is reasonably safe to surmise that the ISN's research projects represent the current cutting edge of soldier-based nanotechnological advances.

technologies used to carry out these functions: (i) the miniaturisation of electronic components, and (ii) the development of materials engineered at a molecular scale to have unique properties (in terms of their strength, flexibility, mass, permeability, appearance, insulating properties, and so on). Here we briefly describe some of the key battlesuit features that the ISN is currently developing, and the technological innovations the ISN is utilising in order to make these features possible.⁸

Ballistics Protection: ISN battlesuits will exploit molecularly-engineered lightweight materials featuring a highly energy-absorbent ‘barbed-wire’ micro-structure, combining stiff polymer chains (the ‘wires’) with strategically positioned pendant groups along the polymer axis (the ‘barbs’). These materials are designed to provide multiple pathways for the dispersion of mechanical energy in order to withstand deformation under sudden impact, whilst maintaining structural integrity.

Blast Protection: ISN battlesuits will incorporate low density materials with carefully designed geometric micro-structures – modelled on cellular solids – in order to provide blast and ballistic protection. These materials will be engineered to insulate soldiers against explosive pressure wave effects, informed by new research into the dynamics of explosive pressure waves and the way in which these waves induce damaging ‘sandwich’ effects for human tissues in contact with external materials.

Enhanced Strength and Flexibility: ISN battlesuits will incorporate strong and lightweight polymer actuators (i.e. micro-scale mechanical devices) with the capacity for rapid and powerful contraction. Modelled on human muscular function, these polymer actuators will serve as external-muscles for the battlesuited soldier, giving him dramatically increased strength (polymeric materials capable of generating a force per unit cross section 100 times greater than human muscle have already been created). ISN battlesuits will also incorporate highly-responsive elastomeric materials with enhanced elastic properties to be used as lightweight protective shields.

Injury Mitigation: Nano-structured contractile polymers will be used to provide ISN battlesuits with instantaneous, localised rigidity, so that they can function as splints and/or tourniquets on specific muscular and skeletal tissues, for the immediate treatment of severe injuries and wounds.

⁸ The information presented in the remainder of this section is summarised from several project reports published on the ISN’s website (Institute of Soldier Nanotechnologies, 2009).

Biochemical Protection: ISN battlesuits will utilise nano-thin coatings and a variety of nano-scale sensing devices (both in-built and dispersible) in order to detect toxins in the soldier's immediate surroundings and nearby areas. The battlesuits will then be able to protect soldiers against biological and chemical threats by adjusting their surface micro-structure and properties to prevent toxin permeation.

Medical Monitoring and Treatment: ISN battlesuits will monitor the vital signs of soldiers, and will be able to non-invasively administer various medicines and pain-relief at the bidding of either the soldier or remotely located medical personnel. Battlesuits will also feature a miniature blood testing 'lab-on-a-chip', capable of carrying out rapid, non-invasive, and highly sensitive blood analysis (in nano-litre quantities) in order to test for exposure to biochemical agents and toxins. The lab-on-a-chip will be able to operate automatically, and will be powered by induced-charge electro-osmosis (ICEO), using small AC voltages applied at microelectrodes.

Prevention of Hemorrhagic Shock: Hemorrhagic shock – the loss of vital bodily function due to blood loss following a traumatic injury – is the cause of many battlefield deaths. ISN battlesuits will detect the imminent onset of hemorrhagic shock via continuous physiological monitoring, and delay its onset using a nano-scale electromechanical delivery system to administer vasoconstrictive drugs, preventing rapid blood loss for wounded soldiers awaiting emergency medical assistance.

5. New Military-Technological Divides?

The ISN's reports suggest that the battlesuit-clad soldier of tomorrow will be very difficult to injure or kill. One of the things that most impresses about the ISN's vision is the multi-tiered protective systems being incorporated into their equipment. If the ISN's plan comes to fruition, the suit of a war-fighter who comes under gunfire or is exposed to an explosion will not only serve to protect his body from wounds, injuries, and burns, it will also compress any injuries he may incur, monitor his vital signs, administer oxygen and pain-relief as required, and in the case of particularly severe trauma, delay the onset of hemorrhagic shock. The ISN motto – “enhancing soldier survivability” – seems entirely apt. For the sake of argument, we will suppose that the ISN's research projects and their mooted applications outlined in the previous section are for the most part technically feasible (at least so far as the ISN's own reporting suggests is the case). We will also assume for the sake of argument that it will be economically feasible for advanced industrial states (the US or others) to manufacture and deploy ISN-developed battlesuits or similar accoutrements on a large scale. With

these assumptions in place, our question once again is whether and how the use of such battlesuits might impact upon the ethical problems which arise in conflicts between superpowers and underdogs, as discussed in §3.

The immediately apparent consequence of the introduction of battlesuits is simply that they will make it even more difficult than it already is for underdog forces to injure or kill superpower soldiers. Granted, the various survival-enhancing functions described in the previous section would not render battlesuit-equipped soldiers invincible; the use of anti-tank weaponry or heavy explosive ordnance would presumably be sufficient to kill a battlesuit-clad soldier. Perhaps we can say, though, that battlesuit-equipped soldiers fighting with superpower forces against underdogs would be largely *invulnerable* to lethal threats. The suggestion here is not that a battlesuit alone will render the superpower war-fighter invulnerable. Rather, the suggestion is that the further advantages which battlesuits confer on superpower personnel, in addition to the usual advantages superpowers enjoy over underdogs (more and better weapons, vehicles, communications equipment, and so on) will mean that superpower war-fighters are only rarely and minimally susceptible to lethal assault by underdog forces. At a minimum, then, the proliferation of nanotech battlesuits would further widen the gulf in the degrees of ease and risk involved for superpower and underdog soldiers trying to attack and kill one another.

This consequence in and of itself is by no means trivial, but nor is it very distinctive. There are numerous technological innovations which have the potential to amplify the military-technological divides, and given what we've said thus far, nanotechnology used in battlesuits might just be another one to add to the list. But there is, we think, something significant and distinctive about the *way* in which the use of nanotech battlesuits could alter the degrees of ease and risk involved for superpower and underdog soldiers engaged in military conflict. Several times in this paper we have noted the differing degrees of threat that superpowers and underdogs pose to one another, and several times we have stressed the point that underdogs often (or at least, in all sorts of typical scenarios) fail to pose a credible threat to superpower forces. There is an ambiguity in this claim, though, because the degree of threat that an underdog poses to a superpower's military forces *at large* is clearly not identical with the threat it poses to an individual war-fighter who contributes to the superpower force. With the military-technological divides as they currently stand, the armed forces of superpower state viewed *en masse* will ostensibly be invulnerable to any threats from an underdog military force. But even so, the lives of *individual* war-fighters fighting for a modern superpower against an underdog *are* highly vulnerable – much less vulnerable than the lives of the underdog soldiers, to be sure, but

inescapably and imminently vulnerable all the same.⁹ This state of affairs is, however, one which the widespread implementation of nanotech battlesuits may be able to transform. If nanotech battlesuits have the extraordinary survival-enhancing capacities that their developers envision, it may soon transpire that the armed forces of a superpower state considered *en masse*, as well as the individual members of that military force, will both be largely impervious to lethal assault from underdog militaries. This seems to us less like a widening of the military-technological divides, and more like a change in the fundamental character of those divides.

This change could have several implications in relation to the two ethical problems discussed in §3. In relation to the guerrilla problem, the use of battlesuits by superpower war-fighters may serve to discourage underdog fighters from even *attempting* to attack and kill superpower soldiers. After all, the risk that underdog personnel expose themselves to in carrying out an attack on superpower soldiers is already considerable. The prospect of attacking battlesuited soldiers who may very well survive a perfectly executed ballistic or explosive assault could make any such risk too forbidding for the underdog to even contemplate. Arguably, then, the aura of invulnerability that battlesuits provide for superpower soldiers could turn out to be just as significant as whatever degree of near-vulnerability they impart. The resort to pernicious war-fighting methods which characterises the guerrilla problem is driven by a perceived absence of alternative strategic war-fighting options (short of surrender) for the under-equipped party. We think nanotech battlesuits would contribute to those perceptions – regardless of how accurate the perceptions actually are – and would therefore have the potential to exacerbate the guerrilla problem. This outcome seems especially likely if the ‘super-strength’ capacities that battlesuits are expected to make possible were advertised (intentionally or not) to underdog military forces. Even if bullet-proof nano-enhanced supermen who can dead-lift a car aren’t a reality, the belief in their reality will only add to the existing pressure for underdog forces to take the battle with superpower forces away from the battlefield. And thus, the threat of violence against non-combatants by underdog militaries – whether that is through terrorism, the use long-range WMDs, the taking of hostages, the use of human shields, or the continued re-emergence of maritime piracy – could well loom larger as the new military-technological divides take shape.

Turning to the problem of riskless warfare, we think the proliferation of battlesuits could transform what is currently a somewhat high-minded abstract problem into an ethical problem which actually impacts on superpower war-fighters

⁹ To cite what is perhaps the most prominent present-day example of a conflict between a superpower and an underdog, U.S. casualties in post combat operations in Iraq (i.e. from May 2003 to September 2009) currently stand at 4195 (see United States Department of Defence, 2009).

on the battlefield. In present-day conflicts between superpowers and underdogs, the life of an individual soldier fighting with a superpower against an underdog remains vulnerable in a range of war-fighting situations, even when the superpower forces at large don't face the threat of defeat. On the current state of affairs, then, the problem of riskless warfare is an ethical problem that the superpower *state* must grapple with, in trying to determine whether and how it can justly engage in military conflicts involving profound military-technological disparities. It is not, however, a problem for the superpower soldier; for if the condition for this soldier attacking and killing his underdog rivals is that his life is genuinely under threat from those opponents, then that condition will be satisfied more often than not. But this situation stands to become more complicated with the advent of nanotech battlesuits. There will still be various circumstances under which the soldier's life is vulnerable, but there will be many more circumstances under which (for all intents and purposes) it isn't. And of course, the soldier will not necessarily be able to reliably ascertain the degree of threat that he faces under a given set of circumstances. All of this serves to place the battlesuited soldier in an ethically compromised situation. To the extent that his accoutrements prevent any non-remote threat to his life, his justification for attacking underdog personnel will be made deeply problematic. But to the extent that he nevertheless finds himself executing orders whilst under attack – still facing the threat of injury, and without any cast-iron assurance as to his own survival – he can hardly be faulted for attacking his attackers in kind. Under the new military-technological divides, then, problems of riskless warfare could arise, in some shape or form, for each individual battlesuited soldier involved in a conflict.

So, where does this leave the soldier fighting for a superpower against an underdog? And how should the superpower state manage the development and implementation of the battlesuit technologies which give rise to these complications and difficulties? In Paul Kahn's work on riskless warfare, he suggests that absent the imposition of mutual risk, militarised conflict between hostile parties ceases to be warfare, and becomes a form of *policing* (2002, p. 4). On Kahn's view, violence against underdog personnel who pose no threat to a superpower is unjustifiable, and instead the superpower should restrict the use of military force to the apprehension or punishment of particular individuals whose conduct warrants the use of force, e.g. violent war-criminals and the leaders of egregiously abusive political regimes. Whether or not we accept the characterisation of superpower military conduct as a form of policing, it seems right to say that principles of warfare are not well suited to governing the conduct of near-invulnerable soldiers. To the extent that superpowers and their personnel are empowered by their insulation from risk, they also take on a burden of responsibility; the challenge for the superpower state is to manage that responsibility in a way that does not expose its own personnel to ethical problems

which they are not equipped to handle. We do not suppose that the survival-enhancing benefits of a battlesuit can be meaningfully weighed against the burden of finding oneself in a morally compromised conflict situation, but at the very least we think superpower states ought to be cautious in embracing such trade-offs.

This does not mean that the US and other military superpower states ought to impose an artificial and untenable embargo on nanotechnological research aimed at ‘enhancing soldier survivability’. The moral challenges thrown up by the changing character of the military-technological divides pale in comparison to the social and geopolitical upheavals that other kinds of technological advancements (nano and otherwise) threaten to initiate. Our suggestion, rather, is just that advanced industrial states need to be judicious in determining when and how they utilise the kind of survival-enhancing equipments being developed by the ISN. The indiscriminate proliferation of nano-battlesuits across all military contexts would increase the likelihood of modern wars being fought unjustly on both sides of the technological divides, by exacerbating the guerrilla problem and bringing the problems of riskless warfare to bear on individual superpower soldiers. By contrast, the selective use such technologies in particular circumstances – say, as part of a cooperative peace-keeping mission – would seem to offer a more favourable balance of survival-enhancing benefits against potential moral hazards. Having said that, though, we want to stress that stand-alone policies to regulate the utilisation of nanotech battlesuits (or special principles to govern the behaviour of battlesuited soldiers) can hardly serve by themselves to sanctify the conduct of military conflicts between superpowers and underdogs. Of course we warmly welcome any measures that advanced industrial states may take in attempting to deal with the challenges that nanotechnological advancements pose in relation to the ethics of warfare. However, we believe that such measures will make little difference to the way that states negotiate the military technological divides if they are not buttressed by cooperative, peace-oriented diplomacy, and by just economic, environmental, and social policy more generally.

6. Conclusion: Replies and Objections

We conclude by anticipating and briefly addressing several possible replies and objections that might be offered in response to our arguments here.

“Nanotech battlesuits will not dramatically increase the survivability of soldiers”: Our supposition that battlesuited soldiers will indeed be very difficult to kill may seem inadvisably credulous. After all, this supposition is based on the ISN’s own reports about the features and feasibility of their research projects, and the ISN has several

reasons (e.g. future funding applications, military secrecy, good old-fashioned self-aggrandizement) to exaggerate or otherwise misrepresent its genuine expectations as to the capacities that its wares are likely to impart to soldiers. More generally, there is no reason to presume that the ISN is immune to the common tendency in the nanotechnological literature (as in several other technological literatures) to conflate theoretical feasibility with technological feasibility, and technological feasibility with developmental imminence.¹⁰ Nevertheless, we have taken the ISN's own reports at face value for the purposes of this study. As we suggested in §1, the technologies and applications being developed in the ISN's various projects occupy the less far-fetched end of the spectrum of nanotechnological possibilities, and these technologies are not summarily dismissed by parts of the wider scientific community as over-optimistic hyperbole, in the way that a few nanotechnological possibilities – in particular molecular assemblers – sometimes are (Smalley 2001). It is worth noting, moreover, that some contributors to the nanoethical literature think it is entirely appropriate (and in some cases even obligatory!) to treat highly speculative nanotechnological visions as genuine possibilities anyway (e.g. Allhoff and Lin 2006).¹¹ So these writers, at least, are unlikely to think it is irrationally credulous for us to have taken the ISN's reports at face value for the sake of ethical discussion. We would also point out, finally, that the military-technological divides and the ethical problems to which they give rise come in degrees. The closer that battlesuited soldiers come to being truly invulnerable, the more salient (and the more pronounced) the ethical problems discussed in §5 become. But then, even if the ISN's battlesuits do not leave superpower soldiers as near to invulnerability as we have supposed for the sake of argument, ethical problems of the type discussed here will still loom in some form.

¹⁰ In addition to these potential causes of inaccuracy, forecasts about nanotechnological possibilities are often plagued by rhetorical inconsistencies, depending upon the discursive context. When significance and attention in the broader public discourse are sought after, nanotechnology tends to be spoken of as an unimaginably potent and world-changing venture; but when critics draw attention to potential social, environmental, and moral hazards of the supposedly impending nano-revolution, nano-scribes will inevitably depict nanotechnology as a more familiar, evolutionary – and in any case inevitable – domain of technological advancement (Sparrow 2007). This is yet another reason to maintain a sceptical stance towards bold predictions about the revolutionary promise of nanotechnological research ventures.

¹¹ We harbour certain reservations about the approach endorsed by Allhoff and Lin. A decision to explore the ethical implications of one remotely possible future state of affairs and ignore the ethical implications of another remotely possible future state of affairs is not ethically and politically neutral. Rather, it represents a privileging of some ethical concerns over others. In our view, decisions about which ethical concerns one prioritises ought to be approached cautiously and reflectively – just because technology *x* and scenario *y* *could become a reality in the future*, then, it does not immediately follow that a discussion of the ethical ramifications of *x* and *y* is worthwhile, or desirable, or salutary.

“Superpower states are not morally responsible for the actions that underdogs take in response to the effects of the military-technological divides”: Our discussion of the guerrilla problem may seem to imply that if a superpower state’s policies contribute to the military technological divides, that state bears part of the moral responsibility for underdog states resorting to pernicious war-fighting strategies *in response* to those divides. Precisely how moral responsibility is meted out in such complex collective action scenarios is far too deep and intractable a problem for us to satisfactorily engage with here. In any case, our arguments only commit us to a fairly moderate claim, namely: that states in general should be mindful of the ways in which their policies (vis-à-vis technological research and development) impact upon the broader context in which international relations are played out; and that states should be judicious and cautious in their technological policy decisions accordingly. We would also reiterate our point from §5, that cautious and judicious policy won’t *necessarily* entail a moratorium on nanotechnological research and development.

“States are always going to develop their military technologies, so there’s no point worrying about the ethical implications of emerging battlesuit technologies”: This kind of objection may represent a broadly realist view about military technological development (i.e. the view that military technological advancement is neither right nor wrong, it just *is*), or it could instead represent a general pessimism about the practical possibility of any attempt to make military technological policy answerable to high-minded ethical concerns. In either case, our arguments are addressed to what we suspect is the majority of readers, i.e. those who reject the notion that the development of new military technologies can ultimately stand aloof from ethical evaluation.

“Technological divides in warfare are continually transforming. The divide between the nano-haves and the nano-have-nots is only transient, and hence so is the influence that any such divide may have upon the ethics of warfare”: That might indeed turn out to be the case as far as anything in our argument goes. Discourse on the ethics of warfare will ideally be responsive to the ever-evolving conditions – cultural, economic, environmental, technological, and so on – under which warfare is conducted, and thus it should examine the ways in which the demands of justice give rise to fresh challenges, and reshape existing ethical problems, as these conditions change. In discussing the emergence of nanotechnology on the battlefield and the ethical implications thereof, our aim has not been to identify ethical problems which will characterise warfare for all time. Our intention, rather, has merely been to explore how perennial ethical problems are likely to take shape under the next generation of military technology. We do not for a moment doubt that subsequent technological advancements –

together with changing social, economic, and environmental conditions – will one day replace these ethical problems with others, both novel and familiar.

7. Appendix: Just War Principles

The following is a brief summary of the normative principles of just war theory, adapted from Brough et al 2007, pp 244-47. We acknowledge that these principles as stated require considerable elaboration and clarification if they are to function as stable normative principles. That task is beyond us for the purposes of this paper, but it has been ably undertaken by many contemporary authors in the JWT tradition; see for instance Coates 1997, Coppieters and Fotion (eds) 2002, Walzer 2000.

Principles of *jus ad bellum* (justice in the resort to war)

1. *Just Cause*. Wars can only be waged in pursuit of a just cause.¹²
2. *Legitimate Authority*. Wars can only be authorised by a political body that is widely recognised as having the power to do so.
3. *Right Intention*. Wars can only be waged if the pursuit of a just cause is the sole or primary motive of the belligerent parties.
4. *Last Resort*. Wars can only be waged if all non-military alternatives to war have already been pursued within reasonable limits.
5. *Reasonable Chance of Success*. Wars can only be waged if there is a reasonable chance that the goals embedded in the just cause will be realised.
6. *Proportionality (I)*. Wars can only be waged if the expected goods of war in a given conflict are proportionate to the expected evils of war in that conflict.

Principles of *jus in bello* (justice in the conduct of war)

7. *Discrimination*. War-fighters should discriminate between combatants and non-combatants and target only the former.
8. *Proportionality (II)*. Military force should be deployed only in proportion to the end pursued in a given war-fighting scenario.

¹² The putative just cause which is least controversial amongst just war theorists is defence of the state against unjust military aggression. The legitimacy or otherwise of several other putative just causes (e.g. defence of an ally against unjust aggression, defence of the state or an ally against the imminent threat of aggression, defending the stability of the international order, or the prosecution of human rights violations) is the subject of lively and ongoing debate within the JWT literature.

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