

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 exacerbate various ethical issues around asymmetric warfare between technologically advanced military powers and technologically disadvantaged 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 twentieth century and early twenty-first century, military conflicts have often been characterised by profound asymmetry between the armed forces of the belligerent parties. There have been relatively few open hostilities between the highly industrialised states of Europe and North America since the end of the Second World War. When these 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 1982 British war with Argentina – or (ii) even more modestly equipped sub-state military insurgencies – as in the US-led counterinsurgency operations in Afghanistan since 2002. In conflicts like these, the military forces of highly industrialised states hold a twofold advantage. First, they have more war-fighting resources: war-fighters, weapons, munitions, ships, planes, tanks, and communications/intelligence infrastructure. Second, these states also enjoy an advantage with respect to the technological capacities of the equipment at their disposal; the militaries of modern industrial states 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.

Our aim in this chapter is to explore the ways in which future developments in military nanotechnology may exacerbate and reshape the distinctive ethical problems to which these divides give rise. While the precise nature and future of "nanodivides" remains contested (Sparrow 2007a), it seems probable that capacity to manufacture weapons with significantly enhanced functionality due to nanotechnology will be confined to a relatively select group of highly industrialised states. Moreover, it is possible that the introduction of nanotechnologically enhanced military hardware will result in larger gap between the capacities of successive generations of hardware than has previously been the case. One of the main impacts of nanotechnology may therefore be to greatly increase the extent of the asymmetry of forces in wars between First World and Third World nations. It is possible that the extent of the asymmetry may become so large that in many contacts between war-fighters armed with the latest generation of nanotechnologically enhanced military systems and those without, the former will be effectively invulnerable to the latter. We will suggest that 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 war-fighters may, on the face of things, be desirable but there is a downside to invulnerability.

2. Just war theory

Contemporary discourse on the ethics of warfare is usually 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 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 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) (Coates 1997; Coppieters and Fotion 2002; Walzer 2000). 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.

In order for the decision to resort to war to be justified, it must meet all of the following six tests of *jus ad bellum*.

1. *Just Cause*: There must be a just cause for war – with defence against an unjust attack being the clearest case of a just cause.
2. *Legitimate Authority*: War must be declared by the proper authority – typically the internationally recognised government of a sovereign nation.
3. *Right Intention*: The primary motive for war must be the just cause that justifies the decision to resort to war.
4. *Last Resort*: All reasonable alternatives to war must have been pursued and exhausted.
5. *Reasonable Chance of Success*: War should only be embarked upon if there is a reasonable chance of achieving the goals established by the just cause.
6. *(Macro) Proportionality*: The goods that the war is intended to achieve must be sufficient to justify the evils that we can expect to result from the war. This

principle must be distinguished from the jus in Bello principle of proportionality (see below).

(Brough et al. 2007, pp. 244–46)

A war that fails to meet one (or more) of these conditions will not be a “just war”. Note that because it is extremely hard to imagine circumstances in which both parties would have a “just cause” for going to war, this means that, at most, only one side of a conflict will ever be fighting a “just war”. However, it is possible – and may even usually be the case – that neither side in a conflict is fighting a “just war” according to jus ad bellum as, even if a nation is fighting for a just cause, the resort to war may fail one of the other tests.

Regardless of whether they are fighting in a “just cause” or not, just war theory also requires all participants in armed conflict to obey the principles of jus in Bello. That is, the justice of the means used in war is independent of the ends for which the war is fought. Thus, for the conduct of war to be just – and therefore for the war “as a whole” to be just – it must also meet the further tests of:

7. *Discrimination*: Conduct in warfare can be deemed just only if war-fighters discriminate between combatants and non-combatants, and do not intentionally target the latter.

8. *Proportionality*: The use of force – and in particular the number of people killed – must be proportionate to the military goals the force is intended to serve. Even attacks on enemy military personnel may not be justified if they might reasonably be expected to result in a “disproportionate” numbers of casualties.

(Brough et al. 2007, pp. 246–48)

For the purposes of our arguments here, we are primarily concerned with the jus in Bello principles of discrimination and proportionality. It is possible that if some of the more speculative claims about nanotechnology came true then this might have implications for jus ad bellum. For instance, if nanotechnological weapons of mass destruction become available then possession of such weapons might justify attacks by other nations under the (controversial – and to our mind implausible) assumption that another nation’s possession of such weapons established a just cause for “preventative” war. Similarly, if a sufficiently powerful nanotechnology were developed by some nations but not others then perhaps nations without access to this technology would never have a “reasonable chance of success” in fighting wars against their technologically superior foes.¹ For that matter, if the development of nanotechnological “assemblers” (Drexler et al. 1991) meant

¹ While we will argue below that nanotechnology is likely to contribute to asymmetry between the military forces of wealthy “Northern” and poor “Southern” states, the claim that it will make it impossible for militarily weaker states to defeat more powerful ones is a much stronger claim and one that we believe is extremely implausible given that victory in military conflict is as often as much a matter of political will as it is of success on the battlefield.

that we entered a “post-scarcity” age then this might remove many of the grounds – and consequently, just causes – for going to war! However, all of these possibilities are extremely speculative and presuppose technological advances that we currently have no reliable way of anticipating. We have therefore chosen to concentrate on issues that we believe might be raised by nanotechnologies of the sort currently under development in materials laboratories around the world today.

3. The ethics of asymmetric warfare

At this point it will be useful for us to introduce some terminology. We will use the term (highly) Industrialised Military Power (IMP) to describe a state that has the capacity to research, manufacture, and field state-of-the-art military technologies (e.g. weapons, munitions, vehicles) and para-military technologies (e.g. information technology or surveillance resources).² Conversely, we will use the term “underdogs” to describe less technologically capable states or sub-state political groups which have relatively modest military capacities in comparison to IMPs.

Expressed in this vocabulary, our suggestion from §1 was that when IMPs and underdogs oppose one another in military conflicts, certain distinctive ethical problems arise due to the extent of the asymmetry between the forces and capacities available to each. To be clear, the suggestion here is not merely that wars between IMPs 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 IMPs, or wars between competing underdogs, or wars involving states and political groups that do not sit comfortably in either camp. 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 IMPs. We will focus on two problems of this type.

3.1 *The guerilla problem*

This first problem arises due to the vast differences in the capacities of IMP forces and underdog forces to injure or kill opposing personnel in orthodox theatre conflicts. In conflicts between IMPs and underdogs, IMP war-fighters can locate, identify, and assault underdog war-fighters who are in uniform or who are openly bearing arms 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

² Strictly speaking, these states are probably “post-industrial” rather than merely “industrialised” – what matters for our purposes is their relative capabilities when compared with other “less-developed” states.

effectively attack IMP forces and, even when the opportunity for a potentially lethal attack does present itself, underdog war-fighters typically carry out such attacks at great risk to their own lives. In short, IMP war-fighters are able to kill and/or maim underdog war-fighters much more easily than underdog war-fighters can kill or maim IMP war-fighters. 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 order to avoid being targeted and killed by opponents with vastly superior intelligence and surveillance capacities, underdog war-fighters will not carry arms openly but will instead try to conceal themselves within the civilian population. This tactic makes it much more costly and frustrating for IMP war-fighters to abide by the requirements of the principle of discrimination. By mingling with civilian populations underdog war-fighters may also be able to provoke the IMP into attacks that will cause large numbers of civilian casualties that will undermine both local and international political support for the IMP's strategic aims. Furthermore, the inability of underdog war-fighters to carry out effective attacks against military targets may drive underdog war-fighters to inflict violence or the threat of violence upon noncombatant individuals, who are relatively susceptible to violent assault, thus violating the principle of discrimination. It may also encourage them to employ weapons and tactics – such as IEDs and car and truck bombings of military targets – that will tend to violate the principle of proportionality by virtue of not having a military goal that would justify the ensuing casualties. Through these methods, while they may not be able to win any military battles, underdog forces may still be able to win a political/strategic victory by undercutting their enemy's will to fight.

To say that underdog war-fighters are driven to violate the principles of *jus in Bello* in these ways is not to absolve underdogs of moral responsibility for those violations, nor is it to re-assign moral responsibility for such actions to IMP 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 IMP 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 the outset. Thus, if the underdog is unwilling to accept military domination, the use or threat of violence against non-combatants and the use of disproportionate force predictably follows.

We can briefly summarise the guerrilla problem as follows. Violations of the principles of *jus in Bello* – especially the principle of discrimination – are more likely to occur in military conflicts waged between IMPs 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 tactics that either directly violate the principles of discrimination and proportionality or that make it extremely costly for their opponents to respect the principle of discrimination.

3.2 *The problem of riskless warfare*

The second ethical problem also arises due to the vastly different degrees of ease and risk involved for IMP and underdog war-fighters attempting to kill their opponents in situations of profound asymmetry. In order to get a grasp of this second problem we first need to turn our attention to a foundational question in the ethics of warfare, namely: why it is that, during wartime, war-fighters in general can justifiably be the targets of lethal violence (assuming with the just war theorist that this is indeed the case). Once war has commenced then according to just war theory – regardless of the justice of the cause in which they fight – combatants may both kill (other combatants) and be killed without necessarily being guilty of murder or the victim of a war crime, whereas noncombatants maintain the same immunity and status they possess during peacetime.

The explanation for this state of affairs clearly cannot be that war-fighters in general are guilty of egregious wrongdoing such that they deserve to be killed or maimed. The rights and privileges that are extended by the doctrine of *jus in Bello* to the combatants in armed conflict are independent of whether they fight in a just or unjust cause and the distinction between non-combatants and combatants is not that former are “innocent” while the latter are “guilty”. The responsibility for the decision to go to war rests with the political leadership of the nation (or sub-state actor) rather than those who fight. Nor can the justification for attacking combatants be that war-fighters have given up their rights in choosing to enlist, for we know that many war-fighters are conscripted, and many more take up the vocation out of economic necessity. Rather than appealing to features or actions of individuals who take on the role of the war-fighter, then, it seems that the answer to this question must appeal to something about the war-fighting vocation itself. That is, in explaining why war-fighters can justifiably be attacked and killed during warfare, we have to make reference to the distinctive capacities and abilities that individuals acquire in becoming war-fighters, and also the ways in which those capacities have implications for other individuals (both combatants and non-combatants) in the context of war.

The just war theorist Michael Walzer (2000) offers such an explanation when he suggests that 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.

Similarly, according to Yale legal philosopher, Paul Kahn, the moral privileges of combatants have their origins in the right to self-defence; combatants in warfare are only justified in attacking one another “as long as they stand in a relationship of mutual risk” (2002 , p. 3).

This account of the foundations of the moral privileges of combatants in a right to self-defence in circumstances of mutual risk is not completely satisfactory. We suspect that it is insufficiently sensitive to the extent to which the ethics of war must be understood as a function of war’s nature as conflict between states (Sparrow 2005). It is because combatants are in the armed services of states that are at war that they become enemies and so come to pose a risk to each other. War-fighters are not, for instance, allowed to target the war-fighters of states with which their own nation is not at war, regardless of how much of a threat these war-fighters may pose at the time. However, while mutual risk may not be a sufficient condition to justify the moral privileges of combatants, it is more plausible to think that it is a necessary condition. In circumstances where the targets of lethal violence pose no risk to those killing them the moral character of individual engagements with the enemy will come to seem less like combat and more like massacre.

To the extent that circumstances of mutual risk are a condition of the ethics of war then circumstances in which one of the parties in conflict is immune to threats from the other are morally problematic. Paul Kahn (2002) has described this as the “paradox of riskless warfare”. It is a paradox because circumstances that establish it are themselves a product of the logic of war. No responsible military leader wishes to meet the enemy in a “fair” fight. Instead, the goal of military leaders and military strategists should indeed be to achieve total battlefield supremacy over their enemies. However, if they actually succeed in this then the justification for the use of lethal force against enemy “combatants” disappears. Enemy soldiers who are incapable of mounting an effective attack ought not to be seen as combatants at all, and should be afforded the same presumptive (albeit still defeasible) immunity from violence that is afforded to non-combatants generally. Thus, Kahn 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). The moral distinction between combatants and noncombatants can no longer do the work required for it and instead the relevant distinction becomes the distinction between guilt and innocence. Forces involved in policing must restrict the use of deadly violence to the apprehension or punishment of people whose individual conduct warrants the use of force, e.g. those actually engaged in the commission of war crimes and the leaders of egregiously abusive political regimes.

We can summarise the challenge posed by riskless warfare for the ethical conduct of war as follows. Violations of the *jus in bello* principle of discrimination are more likely to occur in military conflicts waged between IMPs and underdogs than in wars between forces with relatively similar capacities. This is because (i)

IMP war-fighters will frequently be called upon to attack and kill putative “combatants” in such conflicts, and (ii) the classification of underdog war-fighters as combatants – and the moral justification for IMP forces to attack combatants, which depends upon that classification – is rendered specious if and when underdog forces do not pose any threat to IMP forces (as is at least sometimes the case).

4. Military nanotechnology

Discussions of the ethics of nanotechnology are hampered by the failure of nanotechnology to achieve the dramatic results in application predicted for it and also by lack of consensus about what nanotechnology might make possible in the future (Berube 2006; Sparrow 2007b; Smalley 2001). This difficulty is further compounded in relation to military nanotechnology because military secrecy makes it difficult to know what has been achieved and because researchers and manufacturers need to “sell” their products and their research and the tendency of the media to hype military technologies combine to exaggerate what might be achieved. The most thorough survey of research into military nanotechnology available to date (Altmann 2006) is notable for the extent to which it is forced to discuss what “might” or “could” be done with nanotechnology.

What does seem clear is that “nanotechnology” itself is not a weapon. Moreover, the hypothetical applications of nanotechnology that would rely upon all the components of a military system having properties relating to the nanoscale, such as “smart dust” or swarms of “nanobots”, are the most speculative and the furthest from realisation. Where control over structure of the nanoscale is having most impact is in materials science. In particular, nanotechnological innovation is contributing to (i) the miniaturisation of electronic components (Altmann 2006, pp. 72–73), and (ii) the development of advanced materials which are stronger, more flexible or rigid, lighter or denser, more or less permeable, better insulators or conductors, etc., as required (Altmann 2006, pp. 76–78).

These advances have tremendous military utility but do so because they offer to improve the functioning of familiar types of military hardware. Advanced alloys and composites will provide better protection against chemical and ballistic assault to individual war-fighters as well as to military hardware such as tanks and aircraft (Altmann 2006, pp. 76–78, 84–85; Lau 2002, p. 350). At the same time, the development of new materials, including more powerful explosives, and smaller and more sophisticated electronics, will allow the production of weapons that are lighter, smaller, more accurate, and more destructive (Altmann 2006, pp. 76–82, 85–88; Altmann and Gubrud 2004, pp. 35–36). While we are cynical about the prospects for robots with dimensions anywhere near the nanoscale, it is clear that increases in computer power associated with the development of smaller components due to nanotechnology (Altmann 2006, pp. 72–75), alongside developments in sensor technology, will make it more feasible to develop sophisticated robots

capable of functioning in a wide range of military roles (Altmann 2006, pp. 91–93; Shipbaugh 2006, p. 746; Sparrow 2009).

Rather than talking about the impact of nanotechnological weapons, then, we would therefore prefer to speak of “nanotechnologically enhanced weaponry”. However, even this term misrepresents what we believe to be the most plausible trajectory for the use of nanotechnology in military contexts, which will include a large role for nanotechnology in defensive systems and in other hardware supporting the military in its role of facilitating the use of force in the pursuit of political ends. The appropriate object of analysis then might usefully be described as “nanotechnologically enhanced combat systems” (NECS), where such systems may include defensive systems such as armour plating or the Institute for Soldier Nanotechnologies’ “battle suits” (2009), as well as nanotechnologically enhanced offensive weapons.

5. Nanotechnology and asymmetry

The question we now want to consider is whether and how the development of NECS is likely to bear on the problems discussed in §3 above. If NECS will be used on both sides of future conflicts then they will have little implication for questions of the ethics of asymmetric warfare. However, there are reasons to believe that the possession of NECS will be confined to a small number of highly industrialised military powers for at least the next two decades. While interest in nanotechnology is worldwide and while many nations have research programs into one or more nanotechnologies (Hassan 2005), the vast majority of nanotechnology research continues to be confined to a small number of nations in the wealthy “North” (Sparrow 2007a). The vast majority of research into military nanotechnology is being carried out in the United States, although a number of other industrialised nations, including France, Germany, Japan and (possibly) China, also have significant research programs in this area (Altmann 2006, Chapter 3). Third World or “Southern” nations, on the other hand, are devoting comparatively little of their already scarce resources to military nanotechnology and have little prospect of making significant breakthroughs in this area.

Of course the fact that a technology is researched and manufactured in the North does not mean that it will not be used in the South. Many of the weapons manufactured today are not in fact manufactured for the purpose of national self-defence or even service of the developing state’s military forces but for export, largely to nations in the Middle East and Africa. Thus it is possible that in the future when IMPs go to war in the Third World they will find themselves facing enemies armed with weapons that they themselves – or other highly industrialised nations – have sold them. However, while there is an enormous trade in military hardware, which will undoubtedly extend to include weapons containing nanotechnology, arms manufacturing nations – and especially the United States

– do tend to reserve their most lethal weapons for themselves and (occasionally) their allies. This is especially the case when the weapons systems concerned represent the culmination of many years of development and research and/or provide a significant military advantage over the previous generation of weapons technology. Moreover, the effective use of some NECS – unmanned systems – in their most powerful applications will require a satellite communications infrastructure that is only available to a few highly industrialised nations. Thus the best NECS are likely to remain confined to the possession of those nations that develop them.

Importantly, the difference in capacities between NECS and existing weapon systems may well be greater than that between previous generations of military hardware. Control over the structure of matter at the nanoscale represents a whole new way of producing desired properties in materials. Nations that have mastered nanotechnology will be able to do things – in terms of realising desired applications – that previous material technology could only dream of (as we discuss further below). This, in turn, will allow rapid and dramatic “progress” in the development of lethal weapons and other military hardware (Altmann 2006, pp. 104–105).

When IMP’s meet Third World militaries in the future, then, they will be armed with NECS while their opponents will be armed with “legacy” weapon systems with markedly inferior capacities. Of course, ex-hypothesi, encounters between IMPs and underdogs are marked by asymmetry. What nanotechnology adds to this equation is to further increase the extent of the asymmetry and also increase the chance that in individual encounters between IMP war-fighters and underdogs the IMP war-fighters will be effectively invulnerable to enemy attack.

These developments could have several implications in relation to the two ethical problems discussed in §3. In relation to the guerrilla problem, the use of NECS by IMP war-fighters may serve to discourage underdog fighters from even attempting to attack and kill IMP war-fighters. After all, the risk that underdog personnel expose themselves to in carrying out an attack on IMP war-fighters is already considerable. The prospect of attacking war-fighters armed and defended by NECS may be too forbidding for the underdog to even contemplate.³ In order to have any chance of victory against an IMP, underdog forces will need to concentrate their efforts on “softer” – illegitimate – targets. One significant downside of invulnerability, then, is that one’s enemies will attack one’s compatriots, who are vulnerable. Interestingly, the aura of invulnerability that NECS provide for IMP war-fighters could turn out to be just as significant as whatever degree of near-invulnerability they impart. The resort to pernicious war-fighting methods which characterises the guerrilla problem is driven by a perceived absence of alternative

³ Even war-fighters who are prepared to engage in suicide attacks may hesitate when these attacks are incapable of inflicting casualties on their targets.

strategic war-fighting options (short of surrender) for the under-equipped party. We think NECS would contribute to those perceptions – regardless of how accurate the perceptions actually are – and would therefore have the potential to exacerbate the guerrilla problem. Even if bullet-proof nano-enhanced supermen who can single-handedly lift a tank aren't a reality, the military superiority provided by the possession of NECS will only add to the existing pressure for underdog forces to take the battle with IMP forces away from the battlefield.

Turning to the question of riskless warfare, we think the development of NECS could greatly increase the number of situations in which the ethical issues associated with riskless warfare arise. To date, the phenomenon of riskless warfare has emerged only in relation to military campaigns conducted entirely from the air – and most obviously in air campaigns conducted using Uninhabited Aerial Vehicles (UAVs). In present-day conflicts between IMPs and underdogs, the life of an individual IMP war-fighter remains vulnerable in a range of war-fighting situations, even when the IMP forces at large don't face the threat of defeat. For troops on the ground, war has always been a risky business. However, the development of NECS arguably has the potential to reduce the risk to individual members of IMP forces involved in asymmetric warfare to a level sufficient to trigger concerns about the ethics of riskless warfare.

Three developments in particular might go a long way towards bringing this situation about. First, if nanotechnologically enhanced fabric technologies, such as those being investigated by the Institute for Soldier Nanotechnologies (2009), manage to extend the protection against ballistic penetration afforded to the chest and torso by the best of the current generation of body armour to the entire body of future war-fighters (Lau 2002, p. 350). Second, if improvements in electronics and sensing technology due to nanotechnology make possible the deployment of unmanned systems so as to extend surveillance across the entire battlespace to the point that underdog war-fighters cannot move without being watched and without being vulnerable to long-range attack with precision munitions. Third, if improvements in armour plating or in reactive counter fire systems render vehicles and aircraft immune to attacks by rocket propelled grenades and man-portable missile systems. Together, these developments could render IMP war-fighters effectively invulnerable to small-arms fire from their underdog opponents.

An important qualification to this claim involves improvised explosive devices (IEDs), which have emerged as a potent threat to the lives of US (and allied) soldiers in the current conflicts in Iraq and Afghanistan. The second development, vastly improved surveillance technology, might make it much more difficult for insurgents to plant IEDs and thus greatly reduce the threat posed by these devices. Yet it is hard to imagine any advances in material technology being able to protect individual war-fighters against a tactic that makes possible the employment of artillery and anti-tank rounds against dismounted infantry. While it remains possible for insurgents to deploy IEDs, then, the risk of being killed or maimed will

remain a feature of occupying hostile territory. However, the extent to which the existence of an IED campaign justifies the use of lethal force against enemy war-fighters other than those directly involved in planting or triggering the devices is unclear. Ex-hypothesi, in the situation we are imagining, enemy soldiers not actually involved in executing attacks with IEDs are not a risk to IMP forces. Thus the threat they pose to the IMP forces may be insufficient to establish a general right to fire on opposing forces. Instead, the ethical framework appropriate to responding to an IED campaign may be closer to policing than to warfare, with only those actually involved in carrying out an IED attack losing their right not to be killed.

It is possible, then, that future developments in NECS may significantly expand the phenomenon of riskless warfare. If this occurs, it will undercut the justification for IMP war-fighters to treat all enemy “combatants” as legitimate targets for the use of lethal force. Thus, the second downside of invulnerability is that the moral privileges of personnel involved in the policing actions that may come to replace (some) wars are much reduced; invulnerable soldiers would need to be much more careful about who they kill. If “riskless warfare” becomes sufficiently widespread, the principles of *jus in bello* may need to be revised or extended to address circumstances where one nation may be justified in going to “war” with another but where the war-fighters of the more powerful nation must confine their use of force to targets who may individually deserve to be killed rather than to the class of “combatants” as a whole. At a practical, policy level, the development of “riskless warfare” will leave IMP forces with the dilemma of how to subdue a hostile population without the use of lethal force. Paradoxically, the best weapon for an “invulnerable” war-fighters may turn out to be a non-lethal one.

6. Conclusion

The idea of the invulnerable high-tech warrior has been a fantasy of the military industrial complex since at least the 1960s. Yet for all the human effort and ingenuity dedicated to allowing some people to kill others without being exposed to any risk of being killed in return, this goal remains elusive. New weapons provoke new defences: advances in defensive systems are met with new offensive technologies or new ways of applying existing technologies. The recent history of the US invasion and occupation of Afghanistan and Iraq has shown that a sufficiently determined enemy is still capable of inflicting casualties on the most powerful and technologically sophisticated military in the world. The phenomenon of asymmetric warfare is characterised precisely by the evolution of new tactics to allow a state (or insurgency) to continue to pursue its political/strategic goals in the face of overwhelming military superiority. Thus, the military superiority afforded to some nations by nanotechnology will not mean an end to politically motivated violence. Instead, the nature of this violence will change and with it the nature of the ethical issues faced by parties involved in violent conflict. We have

argued that large increases in asymmetry between forces armed with NECS and those without might dramatically exacerbate the ethical problems of asymmetric warfare. It may place pressure on the just war principles of *jus in bello* by encouraging the resort to tactics that either make it much more difficult to respect these principles or that directly violate them by virtue of attacking non-combatants or by creating disproportionate numbers of casualties without a clear military goal. It may also require the principles of just war theory to be extended to include the ethics of “fighting” an enemy who is, in many circumstances, unable to pose a realistic threat to the lives of war-fighters with the benefit of NECS.

Given the relatively modest contribution made by nanotechnology to contemporary military systems, we have, inevitably, had to frame our discussion in terms of what might or could be possible in the future. However, by focusing on broad-brush technological and political trajectories rather than particular applications we hope we have avoided the reliance on predictions about the future of technological breakthroughs that bedevils many discussions of the ethics of nanotechnology. Nevertheless, it remains the case that, to a large degree, we will simply have to “wait-and-see” whether NECS to provide the level of military superiority that would raise the dilemmas that we have discussed here. The closer that war-fighters possessing NECS come to being truly invulnerable, the more salient (and the more pronounced) the ethical problems discussed in §5 become.

The application of our discussion is also limited by the fact that the particular set of problems we have been concerned with here will not arise in conflicts between parties who are both armed with NECS. We have given reasons for believing that at least some future conflicts between wealthy First World and poor Third World states (or insurgencies) will involve only one party armed with NECS. However, as global climate change continues to accelerate, the relative peace between the states we have described as IMPs may come to an end in wars triggered by mass movements of population or conflict over increasingly scarce resources. We have nothing to contribute here about the ethics of wars between two sides both armed with NECS except to observe that we can see no reason for thinking that the mere presence of nanotechnology on the battlefield will require any revision of the principles of just war theory; it is asymmetry as a result of nanotechnology rather than nanotechnology itself that we believe might generate ethical dilemmas. Moreover, presuming that NECS will eventually become accessible to armed forces and armed militants all over the world, as arms are traded, transferred, or captured across national borders, there is probably a limited number of years in which the issues we have identified here might arise with particular force.

Finally, like many of the ethical issues associated with nanotechnology, the issues we have identified here are not unique to situations involving engineered features at the nanoscale. Indeed, the fundamental origin of these problems is the logic of armed conflict itself. As Hobbes (1981) famously observed, it is the vulnerability of individuals – and political organisations – to violence and the threat of violence

that requires each to prepare for war. Our discussion suggests that the achievement – however fleeting – of invulnerability to violence would come with its own peculiar problems.⁴

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