SCIENCE AND TECHNOLOGY TRENDS: IMPACT ON FUTURE LAND FORCES

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"I know not with what weapons World War III will be fought, but World War IV will be fought with sticks and stones."

Albert Einstein[2]

INTRODUCTION

Armies prepare to fight a nation's wars. War is conflict between groups of humans, and lamentably, it is as old as human society itself. Greek historian and early political thinker, Thucydides, proposed that war was directly related to the nature of mankind and that atrocities would "always happen so long as human nature remains the same".[3] Thucydides' generalisations regarding the human motivations for resorting to war have been distilled into three themes: fear, honour, and self-interest. Although these realist motives are contrasted by idealist perspectives, both viewpoints share the notion that human choices and decisions are central to their philosophy. Moreover, the philosophical examination of war, by military theorist, Carl von Clausewitz, reinforces the perspective that war is very much a human endeavour. Indeed, although the existence of human logic, reason, compassion, creativity, altruism and instinct are acknowledged as components of human nature, the presence of fear, hatred, greed, arrogance, spite, and lust for power, amongst other normatively less desirable human attributes cannot be ignored. Thus it would be foolish to disregard the human dimensions of war as proposed by Thucydides and Clausewitz.

Notwithstanding the fact that it is indeed humans that decide to wage war, whatever their motivations may be, they do not mobilize to fight each other with bare hands – choosing instead to augment their natural human abilities with technology that increases their reach, lethality and likelihood for success. So, while war remains a distinctly human endeavour, warfare is decidedly a human-technological undertaking. Consequently, though the prospect of changing human nature leading to the termination of war should not be ruled out, it is rational to anticipate future

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[1] Defence Engineer with Defence Research and Development Canada, Director Science and Technology Land, currently the Science Advisor for Director Land Concepts and Design.
[2] Purported to be Albert Einstein's response when asked with what kind of weapons World War III would be fought. See: http://www.wagingpeace.org/menu/action/urgent-actions/einstein/
[3] Meyer Reinhold, Studies in Classical History and Society, (Oxford University Press US, 2002). p. 47.

conflict. In fact, it does not require the legendary predictive abilities of Nostradamus to prophesize that there will be heightened competition in the future for dwindling non-renewable resources on a finite planet. To be sure, as needs swell with population growth, so too will conflict; conflict that will undeniably see opponents employing new and novel technologies in their clashes.

Like war, the use of technology in the execution of warfare is as old as human society itself. Certainly the intimate relationship between technology and warfare has been well documented throughout humanity's historical record. Moreover, there is ample empirical evidence to demonstrate the central role that innovative technologies play vis-à-vis shaping the types of warfare that are even possible. In fact, many types of modern warfare would be impossible without scientific, technological, and engineering innovations. A wide variety of examples are available, including: air warfare; submarine warfare; naval warfare; mechanized warfare; chemical warfare; biological warfare; space warfare; nuclear warfare; and cyber warfare.

Given that we can anticipate future conflict, and that it will surely see combatants taking advantage of continuous innovations in science, technology, and engineering, then it is vitally important to remain aware of the emerging developments in these areas. Ignorance of the trends will undoubtedly lead to surprises and perhaps strategic shock, particularly given mounting evidence that an increasing number of science and technology (S&T) areas are experiencing exponential growth.

Exponential growth in S&T will lead to an increasing number of innovations maturing at unprecedented rates. And although there is an acknowledged strong positive correlation between national economic well-being and national strength in S&T innovation, societies cannot be blind to the fact that there are also long-term security consequences and risks associated with the proliferation of increasingly powerful new technologies. For example, the weapon technology with the potential to end all wars,[4] the nuclear bomb, clearly has not done so. Actually, the development of nuclear weapons during WW II demonstrates that societies, when faced with war, will devote enormous resources towards gaining technological superiority over their adversaries. More insidiously, it seems that war distorts human reason (or at least raises the potential for miscalculation) since two nuclear bombs were dropped despite prior risk analysis which stated clearly that nuclear weapons would pose a long term existential risk to modern human society.[5]

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[4] Henry L. Stimson, "*The Decision To Use The Atomic Bomb*", (Harper's, February, 1947), p. 99. "On the other hand, if the problem of the proper use of this weapon can be solved, we would have the opportunity to bring the world into a pattern in which the peace of the world and our civilization can be saved."

[5] Ibid, p. 99.
"The world in its present state of moral advancement compared with its technical development would be eventually at the mercy of such a weapon. In other words, modern civilization might be completely destroyed".

A reasonable lesson to be derived from the nuclear experience is that when faced with threats, political calculus tends to focus on the short term at the expense of the long term - i.e. that the negative consequences of loosing a war (or fighting a protracted war) outweigh even the very survival of the species. That our species has survived, and indeed continues to thrive despite significant nuclear proliferation, is not cause for celebration. The existing global arsenal of nuclear weapons is sufficient to reduce much of the planet to an uninhabitable wasteland and exponential S&T advances only promise to create ever more destructive future weaponry. Consequently, the future of modern society teeters on the balance between human reason and miscalculation.

The dawning of the nuclear age demonstrated the apparently unlimited extent to which human creativity, ingenuity, and determination could be applied towards conceiving, understanding, and harnessing the forces of nature. The magnitude of the power that this new technology placed in the hands of mankind was not lost even on the scientists who helped to usher in the nuclear age. This is plainly evident in the concluding resolution of The Russell-Einstein Manifesto issued in London, 9 July 1955:

> *"In view of the fact that in any future world war nuclear weapons will certainly be employed, and that such weapons threaten the continued existence of mankind, we urge the governments of the world to realize, and to acknowledge publicly, that their purpose cannot be furthered by a world war, and we urge them, consequently, to find peaceful means for the settlement of all matters of dispute between them."* [6]

TECHNOLOGY AND SOCIETY

Technology is ubiquitous and is born of innovation; innovation that is shaped by the social, political, legal, moral, economic, and technical environment that surrounds the innovator. Thus, technology is shaped by human society. But ironically, society is itself altered by technology. Indeed, the entwined nature of socio-technological change is in large part responsible for the evolution of such basic parameters of the human condition as the size of the world population, life expectancy, education levels, material standards of living, the nature of work, communication, health care, war, and the effects of human activities on the natural environment. Other aspects of society and our individual lives are also influenced by technology in many direct and indirect ways, including governance, entertainment, human relationships, and our views on morality, ethics and law.[7]

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[6] See Pugwash Conferences on Science and World Affairs Online. Accessed 29 Apr 2009 http://www.pugwash.org/about/manifesto.htm

[7] Nick Bostrom, Technological Revolutions: Ethics and Policy in the Dark. *Nanoscale: Issues and Perspectives for the Nano Century*, eds. Nigel M. de S. Cameron and M. Ellen Mitchell (John Wiley, 2007): pp. 129-152. Online access 17 Apr 09 http://www.nickbostrom.com/revolutions.pdf

Being mutually interdependent, it makes little sense to treat technology and society as discrete entities. Similarly, it is impossible to separate ‘good’ from ‘evil’ technology. Whether it does good or ill depends not on the technology itself but on what humans choose to do with it.[8] Although its benefits are not shared equally amongst all societies, socio-technological change has lead to unprecedented global prosperity and an enrichment of the quality of life for humankind. Yet while so many aspects of human health and welfare are dependent upon continued S&T progress, paradoxically, the very survival of the species is imperilled by the increasingly destructive potential of accelerating S&T developments. As new tools and techniques continue to ignite unparalleled human collaboration, creativity, and innovation, extraordinary S&T progress is expected throughout the 21st century. This will undoubtedly place ever more valuable but potentially destructive power in the hands of human societies and thereby augment global uncertainty and complexity and thus elevate the severity of the consequences of a human miscalculation or error. Accordingly, an increasingly urgent challenge facing humanity is to leverage the benefits of technology while minimizing the negative and often unintended consequences of socio-technological change.

Overcoming the harmful aspects of S&T advances will not be an easy undertaking if for no other reason than the fact that technological systems tend to introduce a multitude of interdependencies such as those upon electricity, communication and data networks, and security systems. Consequently, societal complexity is amplified due to broad institutional commitments and obligations to guarantee the continuous operation of these systems – systems that have become de facto essential services within modern societies. And moreover, long-term loss of any one of these interdependent systems would undoubtedly lead to cascading failures throughout much of modern society’s technological infrastructure. Acknowledging the inseparability of technology and society, it is logical to conclude that widespread technological infrastructure failures would be followed by societal stress and deterioration. It is contingent upon policy makers, therefore, to make the assurance of socio-technological resilience foremost amongst their priorities.

Shaping policies that will ensure societal resilience while leveraging the benefits of S&T developments will require a cooperative, collaborative, and global outlook. This remains a daunting challenge today because although human creativity, interests, values, and decisions ultimately determine the trajectory that S&T innovations take, there are no unifying regulations, strategies or policies that guide global S&T progress. And despite efforts by the constructive technology assessment community to anticipate effects or impacts of new technologies or new projects with a strong technological component, global S&T innovation and development is so widespread as to make this impractical for anything beyond localized regions. There are in fact a multitude of contrasting and heterogeneous factors that shape S&T trajectories on a global scale. Competing human and societal interests coupled with an ongoing

[8] Alex Roland, War and Technology. (Foreign Policy Research Institute Footnotes, February 2009, Vol. 14, No. 2) Online access 17 Apr 09
http://www.fpri.org/footnotes/1402.200902.roland.wartechnology.html

global diffusion of S&T expertise and governance driven by substantial investment in broad S&T domains by both developed and emerging nations will conspire to make hegemonic control and influence of S&T policy and regulation practically impossible. Such is the nature of the complexity within the global system that modern societies have evolved. Flexibility, adaptability, and resilience must therefore become the cornerstone characteristics of modern societies amongst the growing complexity, uncertainty, and pace of change of the 21st century.

Seemingly paradoxically, science, technology, and engineering advancements are viewed by many as the only viable means by which to create societal flexibility, adaptability, and resilience. Moreover, the well recognized economic benefits of S&T innovation coupled with the eternally present "security dilemma",[9] will continue to provide ample incentive for diverse societies to invest in ever more S&T development. So, while no single entity is in control of global S&T progress, and although humans do indeed exercise their right to choose specific S&T areas in which to invest, there is mounting evidence that the aggregation of these choices throughout humanity's complex global socio-technological system ultimately leads to exponential technological growth. One of the first to study and theorize about this apparent emergent property of modern global society is internationally acclaimed innovator and futurist, Ray Kurzweil. In a series of best selling books,[10] Kurzweil describes at great length a litany of S&T domains that have undergone exponential growth since their inception. He has also developed a general theory to explain exponential technological growth which he calls the law of accelerating returns.[11] More recently, Kurzweil has been appointed as the Chancellor of the newly created Singularity University,[12] an interdisciplinary university whose mission is to assemble, educate and inspire a cadre of leaders who strive to understand and facilitate the development of exponentially advancing technologies, and apply, focus and guide these tools to address humanity's grand challenges.[13]

It is becoming increasingly apparent that those societies that choose to ignore technological exponential growth trends do so at their own peril. Because of the intertwined nature of socio-technological change, the shape that future societies assume due to their adaptation to emergent and continuous exponential technological growth trends remains the source of much speculation and uncertainty. Science fiction writers often revel in painting alarmingly dystopian views of future technology-enabled societies. Although there are also occasionally

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[9] Robert Jervis, *Was the Cold War a Security Dilemma?* Journal of Cold War Studies, Vol. 3, No. 1, Winter 2001.
[10] Kurzweil's books include: The Singularity Is Near: When Humans Transcend Biology; Fantastic Voyage; The Age of Spiritual Machines: When Computers Exceed Human Intelligence; and, Live Long Enough to Live Forever: Your Plan to Extend Your Life Beyond Your Wildest Dreams.
[11] See: Ray Kurzweil, The Singularity Is Near: When Humans Transcend Biology, (Penguin Books, USA, September 2005), pp. 7-14
[12] See: http://singularityu.org/
[13] Although there are numerous domain specific grand challenges, the World Federation of UN Associations Millennium Project maintains a list of 15 global challenges for humanity. Available online, accessed 25 Apr 08. http://www.millennium-project.org/millennium/challeng.html

optimistic, utopian, and clearly idealistic visions of the future, they are in the minority. Interestingly, despite the often dark and dystopian warnings of much historical science fiction, modern society seems to create and implement, with surprising consistency, the very technologies that it has been cautioned against. Few better examples exist than the modern surveillance societies that have emerged despite George Orwell's classic cautionary tale, 1984. The technological developments noted in the next section, the result of converging exponential growth trends across broad S&T domains, will undoubtedly surprise those unfamiliar with the trends. Indeed, much that has been achieved recently remained firmly within the realm of science fiction just a few short years ago. Whether societies will succeed in shaping their socio-technological futures in positive ways, thereby ensuring the long term survival of the species while avoiding catastrophic collapse, remains an open and worrisome question.

Technology Trends

It is important to monitor and understand trends since this helps organizations think about adapting to the inevitable change that will occur in the future, which is the sum of the outcomes of trends, chance events, and human choices. Moreover, it is imperative that trends pertaining to science and technology be analysed due to their acknowledged status as key drivers of change. While it is impossible to predict the future, studying the primary factors contributing to change makes it possible to identify broad possibilities that lie ahead. Negative possibilities constitute a warning, while positive possibilities can reveal opportunities that should be actively pursued – thus allowing for a conscious and rational shaping of the future.

One of the most significant and widely known trends of modern times is the advancement of microprocessor technology, or more generically machine numerical computation. The general public typically associates Moore's Law[14] with the continuous onslaught of ever faster desktop computers – able to now execute billions of numerical calculations per second. An outcome from this remarkably consistent exponential growth trend is that a current multi-core desktop computer can be obtained for a small fraction of the cost but with the equivalent performance of previously top ranked supercomputers.[15] And the processing power of modern supercomputers is astonishing. For example, IBM will build the next world champion supercomputer, called Sequoia, for the Lawrence Livermore National Laboratory and when completed in 2012, it will be capable of 20,000 trillion calculations per second.[16] Coupled with this extraordinary price-performance improvement has been an equally astonishing reduction in the physical volume and power consumption of computing devices. The result of these trends is seen in the portable music players

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[14] Mounting computing power available at decreasing prices has become synonymous with IBM's Gordon Moore and his 1965 prediction that the number of components that could be squeezed on to a silicon chip would double every year or two.
[15] See example: http://www.openfabrics.org/archives/aug2005datacenter/W8.pdf (slide 7)
[16] Lawrence Livermore National Laboratory News Release, NNSA awards IBM contract to build next generation supercomputer. 3 Feb 2009. Accessed online 10 May 2009, https://publicaffairs.llnl.gov/news/news_releases/2009/NR-09-02-01.html

of today that pack as much computing resources as yesteryear's mainframe computers; cell phones (essentially portable mini-computers) that have become ubiquitous the world over, and the demise of film-based cameras.

More importantly, machine numerical computation has been incorporated into virtually every aspect of modern human society. The computerization of society is often generically referred to as 'digitization'. There is barely a human activity within advanced western societies that is not touched or augmented either directly or indirectly by digitization – everything from manufacturing to education to entertainment to health care to warfare has been digitized.

As with all technologies, however, there are both helpful and harmful aspects to digitization. On the upside, numerical computation improves speed and efficiency, enables automation, increases productivity, allows remote operation, and facilitates communication and collaboration. Alternatively, computerization opens up new societal vulnerabilities. These liabilities are in plain view within the mounting volume of reports concerning identify theft and cyber-crime.[17] Actually, the ever present tenuous balance between technological risk and reward is never more evident than in the current debate within the United States over the creation of their so-called 'smart grid' effort.[18] On the one hand, proponents argue that digitization of the national electric power infrastructure is vital for revitalizing a system that has become unreliable and overtaxed by its size and complexity. Conversely, security experts argue in a recently issued press release,[19] that technologies now being rolled out in several cities throughout the country "are susceptible to common security vulnerabilities such as protocol tampering, buffer overflows, persistent and non-persistent rootkits, and code propagation." Moreover they claim that "These vulnerabilities could result in attacks to the Smart Grid platform, causing utilities to lose momentary system control of their Advanced Metering Infrastructure (AMI) Smart Meter devices to unauthorized third parties. This would expose utility companies to possible fraud, extortion attempts, lawsuits or widespread system interruption."

Yet despite numerous warnings, empirical evidence suggests that, on average, the benefits of S&T progress and implementation outweigh its dangerous consequences, otherwise it seems unlikely that humans would have created their complex socio-technological existence. This does not imply, however, that there is any room for complacency lest we fail to heed the warnings of Thucydides or Russell-Einstein. The ostensibly inevitable creation of ever more powerful

[17] A good summary of the current tenuous state of cyber-security is available in the 2009 Data Breach Investigations Report by the Verizon Business RISK team. The report reveals that more electronic records were breached in 2008 than the previous four years combined, fueled by a targeting of the financial services industry and a strong involvement of organized crime. Report aaccessed online Apr 2009. http://www.verizonbusiness.com/resources/security/reports/2009_databreach_rp.pdf

[18] U.S. Department of Energy Pamphlet, The Smart Grid: and Introduction. Accessed online May 2009. http://www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages(1).pdf

[19] IOACTIVE Press Release March 23, 2009. Accessed online May 2009. http://www.ioactive.com/pdfs/AMIPressRelease032309.pdf

technologies indeed only raises the need for greater global vigilance, cooperation, and collaboration focused and guided by empathy, compassion, and good will. As idealistic as this may seem, the consequences of ever more potent technologies being governed by fear, hatred, greed, arrogance or lust for power could mean nothing less than the reduction of human existence to a condition equivalent to that of the stone age.

Notwithstanding the evident tenuous balance between technological promise and peril, proponents are convinced of the nearly unimaginable benefits of its progress and Kurzweil reminds us that technological progress is exponential. Moreover, society has not only allowed, but it has actively pursued pervasive ‘digitization’, which has been facilitated by exponential advances in machine numerical computation or computerization. Now, if we are to accept the notion of the inseparability of society and technology, then we must also admit that with the continued exponential growth of the foundation digitization technology, society will also undergo exponential change. While the success of the human race is testament to its ability to adapt to change, one cannot help but wonder just how much exponential change the species can ultimately accommodate before it hits some fundamental limit. According to at least one assessment, the limit may arrive sooner than many would wish to contemplate, if indeed it has not already been reached.[20]

At least one area of human activity seems to know no bounds – the application of advanced numerical methods and evermore powerful computing resources to virtually every domain of science, technology, and engineering. This ostensible digitization of human innovation is effectively turning all research domains into information sciences, which thereby benefit from the underlying exponential growth of information and computer technologies (ICT). Recently, not one, but two separate advances in machine automation and artificial intelligence serve to highlight the importance and remarkable progress being achieved towards the convergence of human innovation and machine intelligence. In the first instance, researchers at the Aberystwyth University have created what they refer to as automated researchers or “Robot Scientists”.[21] The first, ‘Adam’ is investigating yeast functional genomics whereas ‘Eve’ is investigating drug screening. Meanwhile researchers at Cornell University have taught a computer to find regularities in the natural world that represent natural laws – without any prior scientific knowledge on the part of the computer. They have tested their method, or algorithm, on simple mechanical systems and believe it could be applied to more complex systems ranging from biology to cosmology and be useful in analyzing the mountains of data generated by modern experiments that use electronic data collection.[22]

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[20] See: Donella H. Meadows, Jorgen Randers, Dennis L. Meadows, Limits to Growth: The 30-Year Update (Chelsea Green, June 1, 2004).
[21] Details of the program available online. Accessed May 2009. http://www.aber.ac.uk/compsci/Research/bio/robotsci/
[22] Bill Steele, Move over, Newton: Scientifically ignorant computer derives natural laws from raw data, (Cornell Chronicle Online April 2, 2009) Access May 2009, http://www.news.cornell.edu/stories/April09/NaturalLaws.ws.html

Yet another leap forward in Artificial Intelligence (AI) research, was achieved at the 18th Loebner Prize for artificial intelligence.[23] This prize is the first formal instantiation of a Turing Test – the test named after British mathematician Alan Turing and intended to evaluate whether an artificial intelligence had achieved a level of intelligence that was indistinguishable from human. The 'Elbot' entrant, successfully convinced three of the 12 human interrogators that it could be a human they were communicating with. If Elbot had convinced one other human judge, it would have passed the 30% mark - the threshold set by Alan Turing for deciding whether a machine was capable of thinking like a human. It is unclear whether this threshold will ever be crossed and although science fiction has provided ample dystopian warnings regarding super human machine intelligence, military use of autonomous robotic systems is on the rise by many states. And now robotic platforms are even being armed for direct combat roles. The short-term benefits of using robotic systems to remove humans from dull, dirty and dangerous tasks is well understood. The longer term risk-benefit assessment of increasingly autonomous killing machines, however, has much less resolution and merits continued serious debate.

The ongoing convergence of human and machine intelligence, driven by enormous advances in computing power is combining with innumerable advances in all physical sciences, which is leading to deep understandings of heretofore hidden aspects of our natural environment. Additionally, the convergence of nanotechnologies, biotechnologies, information technologies and cognitive science (NBIC technologies) is a trend that promises to reshape our perception of size and power. Harnessing the unique properties of both biological and non-biological material at the nano-scale promises to dwarf the mega-projects of the 20th century. Indeed, the power of NBIC technologies threatens to eclipse that of nuclear weapons. Therefore, as these technologies mature and continue to converge over the course of the next 20 years and beyond, humankind may unwittingly augment its arsenal of global life-terminating technologies.

Some researchers suggest that the future science and technologies that will matter the most are those that impact upon intelligence and the human mind: brain imaging, cognitive science, neurotechnology, brain-computer interfacing, and Artificial Intelligence.[24] The aggregation of biological intelligence and machine intelligence promises to grant humankind the power to solve any problem in its path.[25] As has already been shown, this level of power must also be accompanied by great responsibility.

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[23] Results for past competitions is available online, accessed May 2009. http://www.loebner.net/Prizef/loebner-prize.html

[24] Future Current Perspectives on Emerging Technologies; The Human Importance of the Intelligence Explosion. Available online, accessed 21 Apr 08. http://www.acceleratingfuture.com/people-blog/?p=185

[25] Humans invariably turn to S&T and engineering to find solutions to problems. Examples include among others: birth control and in-vetro fertilization for fertility issues; vaccines and antibiotics for disease related problems and robotics for labour shortages.

Within the life sciences domain, an increasingly profound understanding of the genome (intra as well as inter-species), driven by advances in information technologies and coupled with inexpensive tools to read and rewrite genetic code, is leading to the ability to manipulate biology at the level of DNA. This offers the ability to re-engineer existing life (for repair or enhancement) and even the creation of new life forms for specific engineered purposes. This ability to manipulate the code of life promises to offer profound capabilities that could be directed towards the solution of humankind's grand challenges – provided that the moral, ethical and legal repercussions, and indeed the growing fear of these technologies, can be managed.

A still embryonic, though growing trend resulting from a convergence of various S&T domains, is that of human enhancement. This is not the type of external or add-on enhancements with which we are generally all familiar – such as fire proof clothing or body armour. Rather, these are enhancements that will directly alter and affect the human body and mind – and nanotechnology is expected to play a major role in this regard. This contentious area is beginning to generate significant ethical debate.[26] Already, significant progress is being made towards treating previously fatal ailments, which is revealing that there are a whole host of knotted issues that need to be resolved since the same techniques can be applied for enhancement purposes rather than therapy. Amongst the factors to be considered are issues of human freedom and autonomy, health and safety, fairness and equity, societal disruption, and human dignity.

Notwithstanding these complex issues, progress in the enabling technologies is rapidly maturing to the point where designing or engineering specific human traits and characteristics is becoming possible. The importance and possible consequences of this possibility cannot be overstated. It amounts to nothing less than engineered human evolution. Throughout the balance of human history, the only means to improve our minds was through extensive education, disciplined thinking, and meditation, whereas improving our bodies demanded a sound diet and intense physical exercise. Today, new technologies promise to enable the creation of stronger bodies and minds without the extensive time and effort normally required to achieve superior performance.

The possibility of attaining superior health, strength, endurance, and intelligence without sacrificing time or effort may at first appear to be a compelling reason for pursuing this avenue of S&T development. Alternatively, the very real prospects for altering human nature in unintended ways, raises the importance of continued focus debate on this issue. Whether these developments result in the change in human nature that Thucydides saw as necessary for the termination of war, or whether they lead to a super empowered individual or small ultra-powerful elite as envisioned by the notorious unibomber,[27] remains beyond our ability to predict. Can we expect the

[26] Patrick Lin and Fritz Allhoff, Untangling the Debate: The Ethics of Human Enhancement. Nanoethics, (Springer Science and Business Media B.V. 2008)

[27] Kaczynski's Unabomber Manifesto, which was published jointly, under duress, by The New York Times and The Washington Post in an attempt to bring his terror campaign to an end, was ultimately

technological promise to outweigh the possible disastrous consequences? Humanity's experiment with nuclear power suggests that short-term interests are likely to prevail even in the face of warnings of future existential risk. We can hope that this does not become a strategy from which the human race cannot recover. Regardless, it would appear, once again, that the optimum approach for maximizing humanity's continued thriving success is via a strategy of cooperation, collaboration, compassion and good will.

As noted earlier, science fiction often serves to raise awareness within societies of the potential for negative consequences due to rapid technological change. Increasingly though, it is often scientists and technology proponents themselves who raise alarm bells concerning humanity's obsession with technology. In a landmark paper published in Wired magazine, co-founder and chief scientist of Sun Microsystems, Bill Joy, presented an elaborate and convincing argument for why humanity's most powerful 21st-century technologies – robotics, genetic engineering, and nanotechnology – are threatening to make humans an endangered species.[28]

Underlying Joy's conclusion is the fact that when viewed individually, technological progress generally represents a sequence of small, individually logical and sensible advances, but when viewed as a whole, they represent an accumulation of great power and, concomitantly, great danger. And although Joy recognized the enormous threat potential of nuclear, biological and chemical weapons of the 20th century, his outlook was tempered somewhat by the fact that building nuclear weapons required access to both rare and fundamentally unavailable raw materials whereas biological and chemical weapons programs also tended to require large-scale activities. In contrast, he viewed 21st century technologies comprised of genetics, nanotechnology, and robotics as equally powerful but more dangerous because they were well within the reach of individuals or small groups. In fact they do not require large facilities or rare raw materials, and knowledge alone is often all that is needed to enable their use.

There are many friction points and uncertainties that will modify the direction and outcomes of these trends. However, human choices, driven in part by fear of certain S&T outcomes will undoubtedly be a primary source of friction that will shape the direction that these trends follow. That there is no hegemonic power governing global S&T policy decision making, however, makes it impossible to predict where human innovation will take us, or how fast it will progress. Furthermore, there is an increasing likelihood that well-intentioned policy decisions will have multiple adverse unintended consequences due to the growing complexity of globalized society. An

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successful. Several online repositories continue to host the complete text of the Manifesto. Readers are referred to paragraphs 171 through 179 for Kaczynski's consideration of future threats posed by technological advances. Online access 18 Apr 2009. http://www.ed.brocku.ca/~rahul/Misc/unibomber.html

[28] Bill Joy, Why The Future Doesn't Need Us. Wired, Issue 8.04, Apr 2000. Accessed online May 2009, http://www.wired.com/wired/archive/8.04/joy.html

ability to rapidly adapt while mitigating the consequences of change will be absolutely necessary for success in the future.

Building the Future Land Force

Enduring human nature, coupled with the destructive potential of ever more potent technologies, places defence and security modernization efforts effectively on the horns of a Dilemma. On the one hand, defence and security due diligence demands that defence forces adopt a mix of conventional war fighting capabilities while continuously incorporating the latest advances in S&T, lest their capabilities lag behind those of potential adversaries. Yet in so doing, they effectively acknowledge the impracticality, and indeed futility, of global cooperation, collaboration, or good will.

Unless and until the technologies that are increasingly being directed inwards – i.e. those focusing on the human mind and body – are able to alter human nature and cognition in ways that mitigate the prospects for future conflict while preserving what it means to be human, then it seems that the most prudent course of action for defence and security forces is to hedge their modernization efforts with a combination of strategies. First, defence forces must maintain modern combat capable forces with the right mix of capabilities that conform to the realities of the current and evolving global security environment. [29] Equally, defence and security forces must build structures that acknowledge and facilitate the potential and likely imperative for global cooperation and collaboration. Fortunately, the latter strategy although nascent, is taking shape in the form of "Whole of Government" initiatives within the context of a "Comprehensive Approach".[30] The former strategy however, is in need of a closer examination, which is the subject of the remainder of this section.

To remain an effective institution into the future, the Land Force must contribute to national flexibility, adaptability and resilience. To prepare for the future, one might ask the simple question: "What are the three biggest emerging areas (technology or otherwise), that will create possible vulnerabilities for our Land Forces?" From a science and technology perspective, as noted in the previous section, there are a plethora of astounding advancements and developments in the fields of artificial intelligence and robotics; genomics/genetics; biotechnology; materials science and nanotechnology; quantum computer technology; information and immersive technologies; and, cognitive/neurosciences, from within which to choose future potential threats to Canadian society. While these areas will undoubtedly be the source of radical and potentially disruptive changes in the future, from a Land Force

[29] See Peter Gizewski, The Global Security Environment: Emerging Trends and Potential Challenges. Annual Meeting of the Canadian Political Science Association, 27 May 2009.
[30] Although beyond the scope of this paper, those interested in this subject are referred to the paper by Lieutenant-General Andrew Leslie, Peter Gizewski, and Lieutenant-Colonel Michael Rostek, Developing a Comprehensive Approach to Canadian Forces Operations, Canadian Military Journal, Vol. 9, No. 1.

perspective, the greatest future vulnerabilities are due not so much to the disruptive developments themselves. Rather, vulnerabilities will result from an inability and/or unwillingness of the Land Force to incorporate the most useful of these developments into its capability development programs. Current Land Force capability development trends are not cause for optimism in this regard. There is a real risk that the Army is mortgaging its future flexibility and adaptability by pursuing conventional capabilities at a rate and scale today that will over-commit future financial resources leaving little, if any room to pursue future developments. As highlighted earlier, the consequence of an overly short-term focus, is an amplification of the potential for future shock and even catastrophe.

The current Canadian Forces intent to essentially fully commit its capital resources for the next 20 years on the development and expansion of conventional war-fighting capabilities should be viewed as an alarmingly risky strategy and an important long-term vulnerability. The justification for this view is found in a recently published monograph from the Strategic Studies Institute of the US Army War College, which indicates that "The likeliest and most dangerous future shocks will be unconventional." [31] Freier suggests that future strategic shock will not emerge from thunderbolt advances in an opponent's military capabilities, but rather, they will manifest themselves in ways far outside established defence conventions. Moreover, they will be non-military in origin and character, and not, by definition, defence-specific events conducive to the conventional employment of the defence enterprise.

The recent terrorist attacks in Mumbai, India should serve as an early warning. During the post-attack evaluation, it was discovered that the attackers arrived on the shores of Mumbai with detailed knowledge of the city, which they gained from studying detailed satellite images of the city (using free services such as Google earth), were carrying commercial handheld GPS sets and were communicating with their handlers via the Internet and commercial satellite phone. This demonstrates a sophisticated use of readily available, highly functional, and increasingly free technologies. Moreover it points to the fact that the technology is extremely easy to obtain and learn to use. This trend will undoubtedly continue, and as commercial technology grows in sophistication, capability, and ease of use, it will easily rival the capabilities available to military and police forces. Part of the rationale for this is that military, and to a lesser degree, police forces, often cannot take advantage of the economies of scale found in commercial technologies since security and robustness concerns often prevent their direct use by these forces. Another factor is that most military technologies have an "in-service" life that is many times that of commercial technologies. Thus there can be several orders of magnitude difference between the performance of a military technology and that of an equivalent commercial technology.

[31] Nathan Freier, Known Unknowns: Unconventional "Strategic Shocks" In Defense Strategy Development. (US Strategic Studies Institute, November 2008). PDF available, accessed 15 Apr 2009, http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB890.pdf

More significantly, however, is a reversal of the historical flow of technologies from the military domain to the commercial environment (such as ARPANET to Internet). As a result, sophisticated technologies now often exist in the commercial sector for several years before they are “militarized”. Moreover, militarization of commercial technologies significantly increases their costs due to the added engineering effort associated with meeting security and robustness standards coupled with the small market share that they command. The Army’s current investment in legacy war-fighting equipment will therefore likely pale in comparison to the investment that will be required to upgrade the information and sub-systems on these platforms to a level that transforms them from museum pieces to state of the art platforms circa 2028 and beyond that are capable of tele-robotic and/or autonomous operation. Failure to incorporate or accommodate this eventual upgrade path in today’s legacy platform investments would leave the Army in a situation where it is encumbered with manned vehicle platforms when many others will have transitioned to tele-robotic and autonomous systems and even begin to focus primarily on cyber warfare. All of this emphasises the greatest future vulnerability for the Land Force – ineffective war fighting equipment and platforms that have no upgrade path, and a procurement system with insufficient flexibility to fix, upgrade, or replace them.

A second anticipated future vulnerability is due to a trend that has been evident for some time in the Land Force. It is the result of a persistent and seemingly pervasive attitude that downplays the importance of science, technology and engineering for the advancement of military tools and equipment. At the recent 26th US Army Science Conference, Professor Phil Sutton, Director General for Research and Technology Strategy - UK MoD, offered an enlightened counter-view regarding the importance of S&T for military capability development.[32] Sutton offered three propositions: (1) that the difference between old equipment and new is entirely due to the application of science, technology and engineering advances; (2) that replacing old equipment with new only gives incremental advantage (however, the world’s best sword is no match for smart munitions); and (3) an equipment advantage (based on new S&T) only buys time - an agile, determined and capable enemy will close the gap (directly or indirectly).

Sutton’s propositions bear further scrutiny in the context of future Land Force vulnerabilities. The first proposition emphasises the importance of long-term, persistent science, technology and engineering funding and development. Without this investment and the S&T and engineering advances that result, there would be no new equipment, and therefore no technological advantage. The second proposition stresses the importance of establishing a technological advantage, but more importantly, the risks associated with falling too far behind the current state of the art. It also suggests that greater advantage will be attained by not simply replacing an old piece of equipment with a newer version. Instead, effort should be placed on innovation - creating a disruptive break from legacy thinking. Finally, the third proposition highlights the importance of flexibility and agility in capability

[32] Phill Sutton, Proceedings, 26th US Army Science Convergence, December 2008. PDF available, accessed 10 Apr 2009. http://www.asc2008.com/pres/Phil_Sutton.pdf

development. Exploitation of new equipment capabilities will require funding flexibility and agility, traits that are never used to describe the procurement system within which the Army capability development community must function. The current focus within the army to commit essentially all of its funds for the next 20 years on legacy equipment only aggravates this situation.

We cannot plan for all future contingencies, nor can we even foresee them all. Interestingly though, a potential future shock remains "shocking", only when we fail to adequately hedge our capability development activities to deal with their consequences. Thus, the more one considers the possibilities and consequences surrounding a potential future shock, and intentionally prepares for it, the more it becomes a regular problem that is treatable with established procedures, equipment and personnel. Therefore, lack of preparation is a key factor determining whether a future event will be considered as a shock. It can be argued that the damage potential of a future event will be inversely proportional to the amount of pre-planning and preparation for that event. But since it is impossible to plan and prepare for all future possibilities, flexibility, adaptability and resilience become force characteristics of utmost importance. The current Land Force capability development trajectory, if left unchanged, will create a force that has the flexibility and agility to operate well in mid-intensity conventional war-fighting. It will, however, have precious little to offer in response to the future unconventional threats envisioned by Freier and others who study the emerging global security environment.

Over the next 20 years, physical pressures – population, resource, energy, climatic, and environmental – are likely to combine with rapid social, cultural, technological, and geopolitical change to create greater uncertainty and instability. Adapting to increasing uncertainty will demand creative, innovative, and unconventional thinking. Unfortunately, and despite concerted effort, capability developers are often slave to traditional thinking – failing to consider the impact of exponential S&T induced change. The nature of immediate and known threats are powerful motivators that tend to constrain military worldviews to established defence norms. Although focusing on short-term and immediate known realities rather than attempting to treat long-term uncertainties may indeed seem like the logical course of action, Thomas Schelling had the following to say about this situation:

> "There is a tendency in our planning to confuse the unfamiliar with the improbable. The contingency we have not considered seriously looks strange; what looks strange is thought improbable; what is improbable need not be considered seriously."[33]

Creativity, imagination and innovation are therefore invaluable traits that must be nurtured within the capability development community. They serve as a counter-balance to the linear and conservative traditional military worldview. Herein lays a third future vulnerability for the Land Force: failing to challenge conventional beliefs

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[33] Thomas Shelling, 'Forward' in Roberta Wohlstetter, *Perl Harbour: Warning and Decision* (Stanford, CA: Stanford University Press, 1962).

by promoting and harnessing the creativity, imagination and innovation of the capability development community risks a future shock on the scale of the Pearl Harbour attack or worse.

It is highly probable that a future shock will manifest (directly or indirectly) from S&T advances in any one of a number of S&T areas, perhaps even multiple concurrent areas. The most likely candidates comprise the subject areas of: life sciences (genomics/genetics/biotechnology/chemistry); artificial intelligence/robotics; materials science/nanotechnology; quantum computer technology; information/immersive technologies; and, cognitive/neurosciences. The aforementioned three “future vulnerabilities” if left untreated will almost certainly make it difficult if not impossible for the Land Force circa 2028 and beyond to adequately respond to the consequences of such an S&T induced shock. While the S&T community is keeping a wary eye on the developments in these fields, there is a growing gap between the knowledge that is being generated through Defence S&T research, and the ability of the capability development community to leverage it with capability hedging strategies.

Conclusion

Creativity, innovation, science, technology, and engineering, all shaped by human and increasingly by machine intelligence, will factor prominently in determining the character of human society into the future. The trajectory that these advances follow remains within the control of societies, however, such control is reducing in direct proportion to the increase in the complexity of human and national interrelationships resulting from globalization. Collective human wisdom and judgement will be crucial in shaping S&T progress and developments in ways that deliver the greatest benefit to humanity while avoiding a conceivable catastrophic end to life on the planet.

There is no shortage of creative ways with which to use increasingly cheap and widely distributed and interconnected computing power - including activities as diverse as civil disaster response coordination and collaboration, or terrorism. These trends present both risks and opportunities for defence and security organizations. Even if the significant changes resulting from S&T advances were to change the very nature of humankind, and therefore the character of future war as suggested by Thucydides, Land Force capability development must still keep up with the pace of change in order to remain relevant and effective. Whether traditional industrial age bureaucratic procurement processes (that continue to be the norm within defence capability development circles) can compete with the agility, flexibility and speed of peer-to-peer net-enabled open collaboration is questionable. Failure to harness the innovative potential of mass collaboration using open hardware and software represents a risk to capability development adaptability, flexibility, and resilience – characteristics that are acknowledged as crucial for future success.