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THE FOURTH INDUSTRIAL REVOLUTION'S IMPACT ON SMALLER MILITARIES: BOON OR BANE?

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Abstract

Even as smaller and less well funded armed forces are still grappling with incorporating computerisation into personnel, supply and other military functions for increased efficiency or effectiveness, this hallmark of the Third Industrial Revolution is already being eclipsed by developments from the dawn of the Fourth Industrial Revolution. Developments like artificial intelligence, autonomous drones, three-dimensional printing and genetic engineering will deeply affect the profession of arms, with armed services from smaller or poorer nations being no exception. Without the deep pockets needed to fully exploit all these cutting-edge developments, small and mid-sized militaries will still have to adapt as best as they can to the changing winds of the Fourth Industrial Revolution while attempting to mitigate any harmful after effects. The industrial and technological impacts of this revolution on the human resource, intelligence, logistics and operational functions of smaller armed forces will be examined and their implications analysed. Accordingly, the overall military influence of the Fourth Industrial Revolution can be assessed and appropriate operational and policy-based advice for smaller armed services suggested.

Keywords: Fourth Industrial Revolution, military, armed forces, small or mid-sized, personnel, intelligence, logistics, operations

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Introduction

Despite the reputation of military organisations as hidebound creatures resistant to evolution, this is inevitable for the armed services. Indeed, military development policies change according to political, socio-economics and geostrategic shifts as small states use alliances, strategic hedging, neutrality and other mechanisms to weather security uncertainties (Vaicekauskaite 2017). But, with the advent of drastic and rapid technological change, smaller armed forces need to adapt more quickly or be left behind. That said, such militaries are on the cusp of ground-breaking and widespread change brought about by the Fourth Industrial Revolution. But, unlike major or great powers who have the resources to fully exploit all the economic and technological benefits brought about by this sudden shift in widely applicable technological progress, mid-sized and small militaries with limited means must try to obtain the most out of future developments, even as they have to grapple with the growing hazards of the Fourth Industrial Revolution, while facing resource scarcity. This paper will attempt to analyse the revolution's positive and negative outcomes as they relate to mid-sized and small militaries, using a framework consisting of human resources, intelligence, logistics and operations, which are operational departments common to all established armed forces. Subsequent sections will examine resultant decisional or policy based implications and conclude with an assessment of whether the Fourth Industrial Revolution should be seen as an opportunity or complicating hindrance for the national security forces of smaller powers. This has salience since the majority of states are not great or major powers.

What is the Fourth Industrial Revolution?

Essentially, the Fourth Industrial Revolution (4thIR) is the latest in a series of relatively sudden and drastic technological changes which have profoundly transformed not only economics, but also societies, national security and other areas. But in order to properly explain the 4thIR, we first need to briefly explain the key technological revolutions that have led to radical human progress.

The First Industrial Revolution took place between the mid-18th to the mid-19th centuries, involving railroad building and steam engine introduction, heralding the transition between dependence on muscles to machines for production and transportation. The Second Industrial Revolution lasted from the late 19th to the early 20th century, ushering in the age of electricity and the assembly line, making mass production commonplace. As for the Third Industrial Revolution, it began in the late 20th century, primarily featured computing power, and made both personal computers and the internet ubiquitous by the 1990s. Hence, the third revolution assisted the higher order cognitive capabilities of mankind, rather than merely enhancing economic potential.

With the 21st century, we are now witnessing the dawn of the 4thIR. This builds on the democratisation of computing power from the third revolution. Tangible facets of the 4thIR include the mobile internet, facilitated by affordable smartphones and tablet computers, integrated and networked advanced sensor technology, and machine learning partnered with artificial intelligence (AI). Furthermore, the

implications extend beyond better computers linked to expansive networks to encompass genetic engineering, 3D printing, renewable energy, and other ground-breaking technologies. All of these developments occurring concurrently, while simultaneously influencing the physical, digital and organic realms, at an ever-quickening pace, makes the 4thIR dissimilar to previous revolutions (Schwab 2017, p. 7-8).

An example of the 4thIR within the military sphere could be the use of armed, autonomous land drones equipped with advanced sensors, and linked to wireless command and control networks where artificial intelligence enabled decision making only requires human intervention when lethal force needs to be used. Several of such drones could be remotely overseen by a single soldier using improved man-machine interfaces which utilise next generation ergonomics or even helmet integrated brainwave detection, doing away with clumsy manual controls like keyboards and joysticks. Together with advanced data analytics which prioritise the most urgent two or three encountered scenarios at any moment for the operator to oversee, this would allow the aforementioned serviceman to coordinate a squad or section's worth of "manpower" in the field. These integrated technologies provide national governments with the means to patrol conflict areas and demilitarised zones from the 20th century which endure into the 21st, while coping with falling birth rates and corresponding shrinking enlistment numbers. Indeed, we could well see such automation of military operations in 10-15 years as nascent samples of such technology already exists. Specifically, South Korea uses the Samsung SGR-A1 autonomous armed sentry system to guard its side of the Korean Demilitarised Zone against North Korean infiltration (Rabiroff 2010), while the US employs a system called "Blue Force Tracking" to enable command and control of brigade[1] sized formations in the theatre of operations (Dunn 2018).

How the Fourth Industrial Revolution Impacts Mid-sized or Small Militaries

Apart from automation on the battlefield, of which the aforementioned land drones are but only one example, the 4thIR will have a profound impact on the military and how it safeguards national security in the 21st century. Since a truly detailed analysis on how armed forces will be affected by the sweeping technological changes to come, will extend far beyond the wordage allowed by this paper, both the 4thIR's positive and negative influences will only be examined with respect to small or mid-sized armed forces, and the analysis will be classified according to the revolution's effect on military manpower, intelligence, logistics or supply, and operations. These categories correspond to the continental staff system employed by most NATO countries and should be familiar to many service members worldwide. Additionally, contextual clarity will be provided via examples drawn from the Singapore Armed Forces as it both qualifies as a mid-sized military based on a US$9.9 billion defence budget for 2016 (about the same as Taiwan or Pakistan) (Stockholm International Peace Research

[1] A brigade is an army or marine unit consisting of between 3000 to 5000 personnel.

Institute 2017), while its active service strength of 72500 (roughly on par with Argentina and Romania) quantifies it as a small force (International Institute for Strategic Studies 2017, p. 326).

How Military Manpower Concerns are Transformed by the 4thIR

All things being equal, large and well-resourced militaries tend to come from states with significant populations and economic critical mass. Prime examples include the US Armed Forces and the People's Liberation Army of the People's Republic of China. Conversely, mid-sized or small militaries frequently belong to nations with fewer citizens and modest defence budgets. Hence, the latter would arguably find it more challenging to recruit and retain sufficient personnel from amongst a smaller national workforce, and fewer funds to offer attractive wages and benefits. However, this perennial manpower concern might be eased once the labour implications of the 4thIR are fully realised.

The 4thIR heralds a drastic shift in importance from labour to capital as technologically advanced automated manufacturing and intangible services provision mean that traditional repetitive skilled labour tasks become side-lined by machines or replaced by far fewer workers in the creative and services industries. For instance, a factory sub-contracted to produce standardised small arms components via Computer Numerical Control (CNC) would be heavily automated and require far fewer workers. Similarly, the growing importance of intangible products like smartphone applications, investment management and other higher order services, which require rarer skill sets or talents mean that those made redundant from automated manufacturing might face long term unemployment, due to the inability to re-skill or be absorbed by new industries. Arguably, such labour displacement will become more prevalent as automated production efficiency increases, lowering marginal cost per unit of production and enhancing economies of scale for companies, which will in turn incentivise the swapping of labour for smart mechanisation. Additionally, higher-end profitable service industries do not require extensive physical capital, which might otherwise be manufactured in facilities which could absorb the newly retrenched, hence making long-term joblessness or underemployment increasingly probable.

According to US statistics, the latest industrial revolution is creating fewer jobs in new industries than the third revolution did in contemporary history. Based on credible estimates, only 0.5 per cent of American labour work in industries founded after the turn of the century, which is eclipsed by 8 per cent of total employees working in new sectors founded in the 1980s and 4.5 per cent employed in new jobs during the 1990s. On the other hand, 47 per cent of the US workforce is at risk of being made redundant (Schwab 2017, p. 37-38). Hence, the cutting-edge developments of the 4thIR boosts productivity by laying off employees, while new jobs serving the latest economic paradigm fail to keep up in terms of staff hired. But even if the applicability of 4thIR employment disruption cannot be perfectly correlated from the US to other nations, it is worth noting that the former is the world's most developed economy, with a proportional college educated workforce surpassing most developing countries and even some industrialised states. If the 4thIR is going to have such a deleterious effect

on US job security, the depressive outcome for workers in smaller and less vibrant economies would be worse.

Furthermore, these developments do not bode well for employee psychological welfare. If current trends are anything to go by, heightened unemployment will create an employer's market where permanent jobs and even long-term contracts are obsolete. If technologically assisted job to labour matching is relentlessly pursued, we might witness a labour market where employers will only pay for the completion of individual assignments or projects, and suitably skilled labour bid for the chance to be awarded such work. Such an arrangement will not only drive wages down but since such workers would technically be self-employed freelancers, employers would not have to pay for fringe benefits, make social security or retirement contributions or even bother with a minimum wage (Schwab 2017, p. 48). In such a mercenary and transactional paradigm where labour is side-lined, and workers' unions lose much influence, plummeting employee material compensation and the loss of job security will drastically erode labour morale.

But, despite such a dour societal forecast, those who meet the medical and educational criteria (a high school diploma or equivalent appears to be the minimum pre-requisite)[2], while still being young enough for enlistment into the military (mid-thirties seems to be the most common enlistment age ceiling), would then, by comparison, find working in the armed services to be relatively worthwhile. Unlike sunset manufacturing or mature industries vulnerable to aggressive 4thIR driven automation, the uncertain anarchic international environment and even climate change means that the armed forces of smaller states will always require personnel for external defence, homeland security, counter terrorism, and both domestic and overseas Humanitarian and Disaster Relief (HADR). Even though robotics, AI and automation, are and will be, increasingly incorporated into the military toolkit, these developments will probably be used as force multipliers and capability enhancers rather than as avenues to trim military headcounts, particularly for smaller states who already have modestly sized armed forces. Hence, if eligible mid-career enlistees join the military, do not run afoul of service regulations, and perform acceptably, they can look forward to relatively long renewable contracts that provide a decently paid career till the age of 45 to 50, as per the retirement norms of most established armed services. There should be little to no concern about job security as much money is invested on the training of service members and it is in the interests of all armed forces to recoup such investments by having personnel serve over the long term. Moreover, another enlistment motivation which would ease recruitment during the 4thIR, is that unlike private sector companies which seek to cut costs by eliminating fringe benefits, soldiers, sailors, airmen and marines, along with their immediate dependents will continue to enjoy medical, housing, social, educational and other supplemental benefits. By offering the stability and traditional features most jobs exhibited in the 1980s, military human resource departments would be coincidental beneficiaries of the 4thIR. Using

[2] The world's most technologically advanced military, and hence most able to benefit from the 4thIR, the US armed forces, has prioritised the hiring of recruits with at least a high school diploma since the 1980s. It is thus logical that smaller national armed services wishing to adapt to the 4thIR would adhere to similar recruitment standards.

the Singapore Armed Forces (SAF) as an exemplar, the improved recruitment environment brought about by the latest industrial revolution can be illustrated.

Historically, soldiering has arguably been somewhat of an undesirable profession. Even the Duke of Wellington, during the Napoleonic Wars, described British forces as being "composed of the scum of the earth – the mere scum of the earth" (www.brainyquote.com). But even though servicemen have never been at the top of the Western social stratum, they are definitely at the bottom of the traditional Chinese social structure. Historical Chinese society recognised four broad castes, which in descending importance were scholarly nobles, peasant farmers, tradesmen and lastly, merchants (Fairbank & Goldman 1992, p. 108). Rank and file soldiers were seen as beneath even traders by excluding them from the recognised social classes along with other untouchables like prostitutes and slaves. The scholars at the top of the pecking order refused to grant recognition to those whose profession mostly dealt with violence (Fairbank & Goldman 1992, p. 109).

As Singapore has a majority ethnic Chinese population, the aforementioned negative ethnocentric perception of an armed forces career still applies to some extent, especially with regard to rank and file enlistment or even appointment to the junior officer corps without the prospect of quick promotion. However, competitive initial annual salaries of between US$17884 and US$58137[3] depending on rank, fairly generous medical benefits, armed forces sponsored educational opportunities to pursue undergraduate degrees and post-graduate qualifications, along with military contributions to service member's retirement funds (https://www.mindef.gov.sg/oms/arc/index.html), have improved the attractiveness of the SAF as an employer. Despite the unavailability or more importantly, classified nature of Singaporean military statistics, in 2016, it was reported in *Pointer*, the official Journal of the SAF, that recruitment and retention rates for the Republic of Singapore Air Force (RSAF) from 2007 to 2016 have improved (Tee *et al*. 2016, pp. 34). Although the air force is not the entirety of the armed forces, for a small state like Singapore, it would be fair to extrapolate the human resource management success of the RSAF, and at least assume that even if the army and navy were not doing as well, at least the latter's recruitment and retention statistics have not deteriorated. Correspondingly, if military enlistments have at least achieved modest progress at the dawn of 4thIR, what more when its disruptive effects fully manifest and being a soldier, sailor or airman, ironically becomes one of the few avenues for the average person to have a "normal" job? Moreover, since a convincing case can be made that small or mid-sized armed forces are best served by a corps of well-trained professionals reinforced by reserves staffed with former career personnel and volunteers, instead of mass conscription (Usiak & Gorner 2018, pp. 211–214), the former less manpower intensive organisational structure should find recruiting quotas easy to meet, with help from the 4thIR's

[3] As *de facto* civil servants, military personnel in Singapore typically receive at least 15 months of salary comprising 12 months of normal pay, 1 month's salary as a year-end bonus, 1 month's performance bonus and usually an aggregate of 1 month's pay given out as a bonus linked to Singapore's economic performance. The minimum and maximum starting salaries quoted are approximations based on the lowest monthly enlistment salary, that given to military musicians at 1590 Singapore Dollars and the maximum enlistment salary of a college graduate who completes officer training as a First Lieutenant at 5170 Singapore Dollars. The rate of exchange used is US$1 to S$1.33 which was accurate in late January 2018.

labour upheavals. Similarly, it can be seen that military recruitment booms when civilian job prospects sour due to economic recessions (Tomsic 2012).

The 4thIR's Impact on Military Intelligence for Small and Mid-sized Armed Forces

Apart from the better human resource prospects outlined in the previous point, the 4thIR has both positive and negative impacts concerning military intelligence for smaller forces. Among the many salient changes worth considering, perhaps the most pertinent would be the role of artificial intelligence as a key enabler in gathering and analysing intelligence on adversary forces.

As can be seen from contemporary history, the proliferation and eventual commercialisation of military technology leads to not only their spread from great powers to lesser states, but also eventually to non-state actors and even individuals. For instance, night vision devices were only issued to frontline troops of the superpowers in the 1960s, became widely available to middle or even small states from the 1980s – 90s, and were commercialised by former Soviet factories after the Cold War to such an extent that even portable devices based on 1960s technology are now available for sale online to civilians. The inevitability of this process where defence research and development expand in relation to government demand and spread to other firms can be seen in Spain and logically applies to other nations as well (Garcia-Estevez & Trujillo-Baute 2014). Similarly, it is not inconceivable that military grade intelligence tasked AI, capable of withstanding cyberattacks, endowed with autonomous learning and analysis capabilities, compatibility with sensors or interfaces in both the physical world and cyberspace, and the processing speed to offer time sensitive recommendations to field or theatre commanders, would first be developed by great powers, be adopted by lesser states over time, and that less capable commercial grade AIs would eventually be bought by non-state actors and rich civilians.

Therefore, while the aforementioned smaller nations still enjoy the use of military intelligence, facilitating AI versus less developed state adversaries or non-state actors like terrorist groups, the former would be able to leverage upon the AI's ability to process vast amounts of data from field sensors and even open source intelligence, objectively interpret such information without being hindered by the bounded rationality and cognitive biases inherent to human intelligence officers, and offer rapid assessments or recommendations to unit commanders as an added source of guidance to the input offered by battalion intelligence officers. Moreover, AIs incorporated into portable devices and fed with inputs from squad or platoon[4] drones, or even wider sources from periodic satellite uplinks, could provide small special forces detachments on stealthy deep cover operations with virtual battalion level intelligence officers providing critical advice, without the burden of an additional human team member. For a nation like Singapore, which relies on conscription for a significant proportion of its armed forces manpower and where conscripts serve for a relatively short period of time, rendering

[4] A platoon is an army or marine unit comprising 15-30 men. A squad has between 8-12 soldiers or marines.

them less skilled in intelligence collation and analysis, as compared to career service personnel who have years to hone their skills, AIs can help plug the intelligence processing deficiencies of draftee junior officers and Non-Commissioned Officers (NCOs). AIs, thus, serve as a force multiplier, which is pertinent for states with smaller militaries.

On the other hand, the proliferation of commercialised "lower order" AIs capable of intelligence analysis to non-state actors and terrorists is an eventuality that all states have to contend with. In Singapore's context, the Southeast Asian region is home to radical Muslim terrorist groups like Jemaah Islamiyah (JI), and various organisations affiliated to the Islamic State of Iraq and Syria (ISIS). Even though members of JI cells (Bonner & Mydans 2002) and supporters of ISIS (Hussain 2017) have been arrested by the Singaporean authorities, and no acts of terrorism have occurred since the early 1990s, the threat of destabilising violence from these and other organisations still remains. If sleeper cells from JI, ISIS or other organisations were to acquire AI units configured for intelligence purposes, they would be better able to monitor and predict the movements of government internal security agents/police, detect weaknesses in the security arrangements of potential targets, run simulations of attacks to fine tune operational plans, and perform other tasks which either make terrorists harder to catch, or substantially improve the efficacy of high profile attacks.

How the 4thIR Influences Supplies and Logistics for Smaller Militaries

Although personnel and intelligence concerns are militarily important, the 4thIR also weighs heavily on how armed forces supply their units and manage their logistics. To better enunciate this process, concrete examples featuring highly probable technological advancements from the 4thIR with respect to autonomous drones, 3D printing, and renewable energy will be used.

Referencing the earlier example of armed autonomous land drones supervised by a single human operator, an associated concept could be independent compact flying drones designed to deliver medical supplies, ammunition, spare parts and other battlefield essentials. Technological developments associated with AI which can randomise flight paths on the way to a specific point identified by a GPS tracker, along with sensors facilitating object avoidance, thereby allowing the drone to fly close to the ground or vegetation, could boost its survivability against attempts to shoot it down. If such mini Unmanned Aerial Vehicles (UAVs) could carry a fair payload, they could revolutionise frontline military logistics, rendering risky manned helicopter supply drops obsolete and enabling units in the field to replenish their vital expendables more reliably with less concern about adversaries severing supply lines. This cannot be dismissed as unrealistic speculation because the private sector is already experimenting with aerial drones for goods delivery (Weise 2016). As the feasibility and efficacy of both military grade miniature logistics and combat drones becomes readily apparent, we can expect to see states investing in their development and production as one of their defence sectors' key industrial capabilities, bolstering both military security and economic productivity (Cimon 2017).

Taking such automation in conflict to its inevitable conclusion would result in supply drones flying into combat zones to replenish the ammunition and/or recharge the batteries of armed drones, thereby enabling smaller armies to control more territory as regularly re-supplied armed drones can sustain operability for longer and have more endurance than humans. Regarding the Singaporean Army, automation of supply delivery for logistics would allow it to sustain operations with fewer personnel and shorter physical supply routes. This is pertinent as Singapore has and is facing declining birth rates (Lee 2016), leading to the real possibility that it might have to operate with less military manpower in the decades ahead.

Turning to 3D printing, which involves manufacturing by printing layer upon layer of plastics to form a solid object based on the specifications of three dimensional softcopy models, this has the realisable potential to be a game changer for logistical supply chains since large (wind turbine parts) as well as small (medical components) equipment can now be fabricated (Schwab 2017, p. 15-16) by 3D printers, which are much smaller and potentially more mobile than current fixed factory capital. With inevitable advancement in technology which yields more compact printers which cost less and manufacture parts at ever faster speeds, it would be feasible for smaller militaries like Singapore's to outfit company[5] sized units with vehicle mounted or towed 3D printers which can then fabricate commonly used but vital composite/plastic spare parts. When assisted by drone deliveries of combat rations, ammunition and other essentials, this substantially promotes unit operational sustainability and has positive implications for force projection and overseas missions.

Concerning the negative national security implications for 3D printing, the earlier mentioned diffusion of technology combined with the greater affordability of future commercial 3D printers would allow disruptive non-state actors like terrorists or insurgents to create weapons components, facilitating arms acquisitions for attacks and sabotage. Inasmuch as current technology already allows civilians to print plastic gun parts which are durable enough for one sustained assault (Farivar 2013), this potentially means that terrorist cells need only obtain selected metal firearms parts (e.g. the barrel) to assemble improvised arms. With less that needs to be smuggled as contraband, there is a lesser likelihood that potential terror operations could be detected and pre-emptively stopped. Despite the draconian gun regulation laws of Singapore, this partial democratisation of firepower should have significant implications for counter-terrorist policy and its implementation, making the jobs of customs and excise agents, along with the counter-terrorist commandos of the SAF, that much more challenging.

Lastly, the introduction of advanced material technology coupled with ultra-efficient energy transmission and storage methods as part of the 4thIR, could lead to the realisation of practical renewable energy via compact solar panels for use by the military during field deployments. Current solar energy technology requires large areas to site enough solar panels for the harnessing of

[5] A company consists of between 80-150 soldiers or marines.

sufficient useful energy. This is feasible for civilian applications but not for armed forces expeditionary requirements.

When the 4thIR delivers on mature solar panel systems as a renewable energy source, armed forces outfitted with such technology would possess enhanced deployment endurance. Without the need to consume valuable fuel or at least use less diesel/jet fuel to run generators for electrical power, military units at the front would be less dependent on vulnerable logistics lines for fuel replenishments. Also, when coupled with the previously highlighted use of aerial drones for ammunition, food and other vital supplies, along with the utilisation of stored solar power to recharge batteries for 3D printers producing spare parts, forward deployed units of the future may well exert much smaller logistics footprints. As for mechanised units, the load bearing, and performance requirements of army/marine corps vehicles would preclude them from being totally electrically powered and recharged from solar panels[6] but at very least, running these vehicles' communications systems and ancillary equipment off solar energy recharged batteries would enhance fuel efficiency, thereby extending operational reach.

For smaller militaries like Singapore's, renewable energy and its associated cost savings and/or efficiency enhancements might mean the difference between preserving current capabilities and operational tempo or being compelled to implement cut backs due defence budget shrinkage from severe economic downturns or domestic political changes. With respect to darker national security implications for renewable energy, commercially available versions of military style solar panelling could enable terrorists to set up self-sustaining training camps in remote locations, without connecting themselves to the pre-existing energy grid or relying on noisy generators. This increases the odds that such clandestine facilities will go unnoticed for longer. Although Singapore is small, making such camps easily detectable on its soil, such covert and logistics light facilities in nearby countries like Indonesia and the Philippines would provide an avenue for the former's radicalised citizens to receive training and indoctrination, readying them for disruptive activities upon their return home as covert cell members.

Military Operations for Small and Mid-sized Forces in the Age of the 4thIR

After exploring how the 4thIR influences military manpower, intelligence and logistics, we now examine how it transforms the conduct of military operations into forms vastly different from that seen in the last century. This analysis will be accomplished from the standpoints of how forces are organised to fight, where they will increasingly fight in the years to come, and how actual combat will change.

[6] Sunlight reaching the earth is currently rated at 164 watts per square meter over 24 hours. (The Basics of Solar Energy [online]. *University of Oregon*. Accessed February 4, 2018 http://zebu.uoregon.edu/disted/ph162/l4.html). On the other hand, one horse power (hp) equates to 735.5 watts. As the average US military "Humvee" light utility truck has a 190hp (139735 watts) rated engine (M1165A1 HMMWV [online]. *AM General*. Accessed February 4, 2018 http://www.amgeneral.com/wp-content/uploads/2016/08/M1165-1.pdf), a similarly rated electrical engine would need require about 852 square meters of solar paneling exposed to several days of sunshine to recharge itself. This is militarily unrealistic.

With reference to the mobilisation or organisation of forces to fight, the increasing ubiquity of smart phones which never leave our sides, social media, and tangibility of online presence for much of the youthful population, have provided discreet and effective means for mobilising substantial numbers of personnel for kinetic operations. Unlike during the early 1990s and before, where platoon and squad leaders had to be contacted by landline phone calls or pagers, in order for them to manually inform their men to report to garrison for marshalling, the "call to arms" of the present and near future simply involves a mass message to all the smartphones or mobiles owned by every soldier summoning them for immediate duty. Such improvements in communications interconnectivity conceivably allows about 3 battalions (900 – 2400 men) of personnel to be discretely called up, gathered and organised for field deployment within a matter of hours as opposed to an entire day. With further technological development as the 4thIR progresses, and our online lives become ever more entwined with the physical world, the speed and size of such low-profile force mustering will likely rapidly increase. Even if larger bodies of troops need to be called up, the practice of openly summoning such units via mass media radio, television and even cinema announcements, as the SAF currently does, should be consigned to the past. Consequently, gearing up for conflict or mobilising to send a deterrent message should not alarm the public.

Inasmuch as small and mid-sized armed forces will eventually acquire such seamless and rapid troop mustering capabilities, upholding a certain "balance of speed" where organised militaries lose the capability to achieve tactical surprise, which lessens the destabilising temptation for pre-emptive strikes, a greater worry is that violent non-state organisations might use advanced personal communications to launch surprise attacks. Unlike years past where phone calls might not be used for fear of surveillance by authorities, and terrorist leaders resorted to coded messages placed in pre-planned hidden locations, or even instructions innocuously incorporated into newsprint classified advertisements, multiple simultaneous attacks today could be triggered via coded messages sent using encrypted popular smartphone chat applications like WhatsApp. Assuming that clandestine logistical preparations – which by themselves should seem innocuous, are done beforehand – this potentially shortens the terrorist mobilisation and organisation phase from days to a mere several hours, shortening the window of opportunity for security forces to detect and foil such plots.

More worryingly, smaller nations like Singapore, which seek an economic competitive edge by encouraging internet access, IT literary, and the increasing digitisation of social and economic life might be opening themselves to greater danger from internet savvy terrorists. Just as the 4thIR has spawned the on-demand economy of online platforms which provide services but owns no assets – like Uber, the taxi firm which owns no vehicles, or Airbnb, the accommodation provider which owns no real estate (Goodwin 2015), we might well be facing the reality of "insurgency or terrorism on-demand". Such an insidious concept could entail the setting up of platforms or websites in the "Darknet" (that part of the internet accessible only with specific software, configurations, or authorisation and often using non-standard communications protocols), where terrorist leaderships and their material sponsors put up "advertisements" to attack specific targets or people, promising

payment in very hard to trace cryptocurrencies like Bitcoin, for individuals or cells willing to make contact and provide proof of a successful attack. Alternatively, such clearing houses for contracts of violence with a religious orientation could offer to provide volunteer cells with physical logistics assistance for attacks and thereafter, glorify the subsequent attacks while offering spiritual justifications and otherworldly rewards for the now dead terrorists, in essence, a kind of “Jihad.net”. Despite the intense societal surveillance that well-resourced small states like Singapore can bring to bear, the clandestine nature of darknet based “violence on-demand” makes for a tough and insidious challenge.

Having described the rapidity and even covert nature of force marshalling in the 4thIR, the question of where they will fight will next be analysed. As previously explained, the changing nature of production and rapidly evolving labour requirements will produce ever worsening societal inequality. This will exacerbate discontent and disillusionment with established authority and social structures. With more dissatisfied people struggling to find meaning in a world transformed by the 4thIR, it will become easier for radicalised movements and violent organisations to find recruits willing to lash out against the changing system which has marginalised them (Schwab 2017, p. 81). As the population of those who have nothing to lose increases, destructive and extremist ideologies will arguably find more adherents.

In this milieu, armed forces will have to fight in a fluid human environment, coming to terms with the reality that they will not only have to contend with easily identifiable state organised combat units, but also and more increasingly, non-uniformed fighters who are frequently indistinguishable from civilians, but in their own unconventional way, just as dangerous as state raised and deployed forces. For instance, what appears to be a pregnant woman crying out pitifully for help is actually a fanatical suicide bomber hiding several kilos of high explosive under her maternity dress. Such unconventional combatants often have the element of surprise on their side, as well as superior area knowledge, allowing them to determine the when and where of ambushes, much as the *Vietcong* and North Vietnamese Army did to US forces during the Vietnam War from the 1960s to the early 1970s. This new operational paradigm presents an acute challenge to not only existing rules of engagement or procedures guiding soldiers in the use of lethal force, but also the mind-sets that soldiers take with them on deployments to such confusing environments. It would be fair to say that all militaries, both large and small will inevitably have to learn to cope with a myriad of antagonists ranging from fanatical militias (e.g. ISIS), to criminal gangs (South American drug cartels), hostile but unarmed civilians, and disguised saboteurs, amongst others. Even troops from smaller nations like Singapore might have to cope with such entities when sent abroad for UN peacekeeping missions or other coalition driven campaigns.

Aside from the aforementioned greater complexity in human geography encountered, governments, armed forces and even large companies will increasingly find themselves engaging adversaries in the non-physical online cyber domain. The increasing prevalence of cyber connectivity and virtual links

with government, military and corporate entities in the 4thIR, are and will more pervasively expose them to all forms of cyberattacks from viruses, to data theft and even attempts to hijack entire IT systems. This new dimension necessitating vigilant defence cannot be ignored because as long as no fatalities occur, its non-physical nature and unregulated status under international law, makes it difficult for any nation to classify cyber assaults as a *casus belli* justifying retaliation via conventional military force. Hence, in any conflict between states or against non-state actors, it is in the interests of both sides to execute online offensives against each other to disrupt or even destroy the other's infrastructure, sensors, communications and decision-making capabilities.

Moreover, cyber warfare as both a phenomenon and environment for belligerence is a case of acute concern because of *what* can be targeted as well as *who* is doing the attacking. In terms of vulnerabilities, cyber offensives are not limited to military targets and can include civilian energy, medical, water, transportation and financial infrastructure. Disablement of any of these vital service's IT systems will lead to serious panic, disruption to normal life, social unrest and long-term loss of confidence in the government's role as a guarantor of stability. With such weighty implications, military cyber defence personnel would have to shoulder at least some of the burden for cyber protection of crucial civil infrastructure. Regarding the attribution of cyber hostility, the massive inter-connectivity of the 4thIR means that enemy states are not the only antagonists. National assets or even key corporations could be the hostile focus of terrorist groups routing their attacks through neutral third countries, vindictive individuals with the proverbial axe to grind, cyber mercenaries hired via the darknet through the aforementioned "insurgency/terror on-demand" websites, or even an advanced AI that has gained sentience!

Considering the above, even small states should take cyber defence seriously. Illustrative cases where lesser states were subjected to cyber-attacks in order to erode the morale of their populations include Estonia in 2007 and Georgia in 2008 (Stapleton-Gray & Woodcock 2011). Accordingly, Singapore, as the smallest but most developed and IT connected nation in Southeast Asia, has taken steps to defend its military infrastructure in cyberspace. Even as it has no avowed enemies, one of its military databases was hacked and data stolen in February 2017 (Chua 2017). Consequently, the SAF established a "Defence Cyber Organisation" to protect its interests from hacking and other cyber hostilities (Cheng 2017).

While senior officers trained in the 1990s might wish for a defence paradigm frozen in the early 2000s, it is better for them to accept that the opening shots in the next war might not be fired by troops, aircraft or warships, but by a group of anonymous hackers working from laptops through public wireless internet access, having been engaged through an anarchist webpage on the darknet by an entity using a false front, wiring them payment via cryptocurrencies, to remotely shutdown the life support systems of a military hospital, thereby inflicting casualties in a non-attributable way. Such a frightening prospect becomes ever more likely as the 4thIR progresses.

Finally, the issue of how the 4thIR will influence actual combat or warfighting will be addressed. Perhaps the most tangible and realisable operational manifestation of the 4thIR is battlefield automation. Like the earlier mentioned combat and resupply drones, many militaries have already deployed aerial drones for combat and reconnaissance missions. From amongst the ranks of small and mid-sized forces, both Singapore and Croatia have deployed the Hermes 450 and BL M-99 Bojnik drones for airborne surveillance respectively. As sensor, AI and other technologies advance, land and maritime drones will become increasingly common.

But unlike the manufacturing and some service sectors where robotics replace humans; armed drones, as illustrated in an earlier part of the paper, can act as force multipliers functioning under periodic human supervision to perform missions too dull for human vigilance, too lethal for casualty adverse electorates, and/or in areas too contaminated for human presence. Upon the maturation of such technology and when manufacturing capabilities achieve economies of scale, the increasing affordability of military drones will provide a viable option for smaller armed forces to put "boots" or rather threads or wheels on the ground, where nationally claimed territory went unattended in earlier eras. Hence, forces like Singapore's need not be constrained by smaller populations or recruitment sources, being able to deploy "machine troops" for mundane duties. Alternatively, the development of AI and machine learning could result in combat drones assisting human troops in close proximity, the former being placed under the control of specially trained human handlers, "taking bullets" to save their human overseers when necessary.[7]

However, the automation of kinetic force has its dark side. Inasmuch as nations are driven by national interest imperatives, certain governments might decide that the ends justify the means. In these instances, their militaries could be directed to deploy autonomous lethal drones in substantial quantities without the requirement of final human approval before targets are killed or destroyed.[8] At the very least, such drones could be unleashed upon adversary political or military leaders that rival states deem threatening, allowing national leaderships to play the part of "judge, jury and executioner", but other more chilling implications are that a drone swarm might be used for genocide, targeting people of a specific ethnic appearance or that terrorists might acquire several dozen drones, unleashing them near a political rally where national leaders are present. Those who dismiss drone swarms as ethically unfathomable and technologically unrealistic would do well to note that South Korea will be working on such technology to deal with the threat from North Korea, while the US has been experimenting with such a concept (Kwong 2017). The employment of remote systems and autonomous systems may also lower the threshold for violence amongst decision-makers, inasmuch

[7] As seen from the 2015 science fiction film "Chappie", distributed by Columbia Pictures, advanced robotics were paired up with human police officers to deal with heavily armed criminals. Similarly, it is not difficult to imagine humanoid combat drones accompanying human soldiers into battle. The relevant scene can be viewed on YouTube at https://www.youtube.com/watch?v=dcq8bPs5y8M.

[8] There already exists an on-line campaign to oppose the introduction of autonomous weapons systems. The website, "Ban Lethal Autonomous Weapons", can be found at https://autonomousweapons.org/. A rather worrying video about the implications of such weapons being deployed under the justification that their precision eliminates collateral damage can be found at, https://www.youtube.com/watch?v=HipTO_7mUOw.

as actual blood may not have to be spilt with its attendant political costs, if inanimate or uninhabited targets are attacked. Moreover, the 4thIR enabled production of large numbers of smart, affordable combat drones might even erode the combat superiority of developed nations' armed forces (Hammes 2015), making the resort to force a more tempting option for otherwise weaker states.

But despite a forecast of a heavily mechanised future, the 4thIR could instead alter us biologically at our most basic level, that of DNA.[9] If the predictions of optimistic futurists come true, and gene editing becomes a reality such that not only can fertilised human embryos be engineered to produce "designer" children, but that adult humans can have their DNA re-written to modify their physical characteristics (Schwab 2017, p. 22-23), without unacceptable health risks, soldiers in the next conflict could be substantially enhanced, leading to interesting outcomes.

Setting aside the moral, philosophical and religious objections to genetic engineering, being able to alter the genetics of future generations of soldiers, airmen, pilots, sailors and marines would not only forever silence Lord Wellington's "scum of the earth" assertion about military human resource quality but, assuming that training qualitatively improves to exploit vastly improved enlistee quality, lead to big jumps in operational efficacy. For those servicemen and women who volunteer to have their genes re-written with the 4thIR's biomedical advancements, 21st century militaries could see personnel with better than perfect eyesight, hearing, and smell, heightened disease resistance from robust immune systems, faster recovery from fatigue and injuries due to tweaked metabolic rates, physical reflexes and endurance on par with Olympic athletes, pain tolerance at the edge of human potential, and physical strength at the top percentiles of the human population. If improvements in cognitive capability or intelligence can also be had with DNA engineering, the best individuals for military service can be created. Hence, there would be superior trainee pools for potential combat arms personnel, helicopter and fixed wing aircraft pilots and special forces operators.

Regarding the applicability of gene modification technology for small and medium sized militaries over the first one to two decades – when costs still remain high due to a lack of economical extensive DNA editing methods – much depends on the financial resources available to these states. While large militaries belonging to the well-heeled major powers like the five permanent members of the United Nations Security Council, could field anything from dozens of battalions to many brigades of genetically enhanced troops, leading to far more effective elite front line units – which could conceivably fight and win against conventional non-augmented troops which outnumber the former – smaller militaries operating on modest budgets would have to accept that they would have at their disposal, at most only a few companies of DNA customised personnel. Be that as it may, distributing and allocating such individuals to maximise operational impact will be a key consideration. Based on conventional wisdom, pilots, special forces and even police SWAT teams tasked for counter terrorism

[9] Deoxyribonucleic acid (DNA) is the chemical name for acidic substance present in all organic cells containing the genetic instructions used in the growth, development, functioning and reproduction of all known living organisms.

would have priority for such premium manpower. Referencing Singapore as an example of a mid-sized military's defence budget mated to a small armed force's manpower, it can be argued that Singapore in the 4thIR would at least try to raise of force of 3 battalions (900 – 2400 men) of such genetically boosted troops. These can then be allocated amongst the city-state's combat aircraft pilots, special forces, elite airborne infantry, and if any personnel are left, the Singapore Police Special Tactics and Rescue (STAR) team.

But even though genetic engineering holds the promise of creating "super soldiers", governments and societies need to remember that given enough time, technology will eventually proliferate to allow rogue states and even terrorist organisations with rich sponsors to acquire their own DNA augmented combatants. Other than the possibility of unsavoury nations like North Korea paying unscrupulous scientists to develop domestic genetic development programs, it is also possible that states like Iran might send their augmented soldiers overseas as "active consultants" to aid violent proxies like Hezbollah. Lastly, soldiers with modified genes are still human and vulnerable to ideological influence. Some of them might be swayed by the propaganda of radical beliefs, leading them to dessert or defect to violent organisations. Alternatively, older "boosted" soldiers who have been honourably discharged after completing their service contracts could still be militarily useful. If such individuals are still healthy and in their mid to late forties, a minority of them could be tempted to work as well-paid mercenaries for terrorists or insurgents. Indeed, such old commandos should not be scoffed at, as they bring with them decades of combat experience and are capable of causing much mayhem to unprepared security forces.

Further Military Implications of the Fourth Industrial Revolution on Smaller States

The 4thIR is a double-edged sword bestowing blessings and inflicting curses. When discussing military recruitment, it could be a boon to mid-size or small armed forces, as more citizens become prepared to consider a career in uniform. With a labour market where more new and mid-career jobseekers are drawn to the stability and benefits from career armed forces enlistment, it should be noted that armed forces of small states like Singapore will notice a marked improvement in the quality of career service candidates. Better educated, skilled, talented and motivated recruits will in turn, all other factors held constant, lead to greater operational efficacy. However, over time as it becomes the "new normal" for the armed services to be seen as a desirable and even prestigious job option, armed forces human resource policymakers should resist the temptation to cut costs by eliminating benefits, in the belief that quality enlistees will still clamour to serve as other career options diminish in the 4thIR. This is ill advised as soldiering still carries risk and comes with hardship. The last thing that national defence ministries and departments of smaller states want, is for their limited citizen recruitment pools to shrink due to cost cutting induced job seeker disillusionment, or worse, to have the aforementioned manpower consider "work" with the criminal sector or terrorist organisations.

Turning to military intelligence, the use of AIs fed with sensor and open source data gives smaller militaries the decision-making edge vis-à-vis non-AI equipped enemies. Furthermore, smaller armed forces dependent on conscription, like that of Singapore can use military intelligence suited AIs to make up for the analytical experience shortcomings of draftee personnel. However, since the proliferation of technology is unavoidable and even violent non-state actors will eventually acquire lower order AIs for intelligence interpretation and mission planning, it behooves all less endowed militaries to continually upgrade their AI capabilities as much as funds and technical competence allow, while training intelligence officers to make the most effective use of assigned AIs, in order to maintain an edge over all identified threats.

From the perspective of military logistics, the 4thIR brings much benefits. From the probable introduction of reliable UAVs for battlefield resupply, to field transportable 3D printers for frontline spare parts fabrication, and the use of renewable solar power for 3D fabrication, sustaining electrical systems and supplementing automotive power, military units of the 21st century would be more mobile, less tethered to supply lines, and possess greater operational endurance. This potential to accomplish missions while replying less on military logistics channels means that lesser populated states like Singapore can still field useful armed forces by decreasing the "tooth to tail" ratio[10], enabling the maintenance of adequate military force despite economically driven or politically motivated budget cutbacks. Although terrorists and other violent antagonists will also use the logistics boosting 4thIR technologies like 3D printing and renewable energy, to help arm themselves and conceal their hideouts respectively, it can be argued that on the whole, these technical innovations bring more benefits than challenges to smaller armed forces.

Examining the implications of 4thIR influenced operations by less endowed militaries, it was elaborated that the widespread popularity of smartphone and internet use gives rapid troop mobilisation capabilities to not only established armed forces but also allows terrorists to surreptitiously and quickly activate pre-existing cells for operations. However, a more vexing concern is the use of the darknet as a terrorism dispatch centre matching attack cells with well-resourced sponsors. This makes attack pre-emption by security forces increasingly difficult while giving terror sponsors unprecedented confidentiality. In this regard, the 4thIR is more bane and boon, which is a similar theme carried forth into future combat environments. Such environments could well be populated by non-uniformed militias, hostile civilians and disguised terrorists, who's numbers might be partially be drawn from the discontented who have been marginalised by the 4thIR. How state organised forces, both big and small reinvent their rules of engagement to meet this challenge will significantly affect their future mission effectiveness.

[10] The tooth to tail ratio refers to the number of logistics or support troops need to sustain the fighting efforts of combat soldiers. A high ratio means that many supply or service support personnel are needed to support just one war fighter.

From the physical to the virtual milieu, the narrative of challenge is reinforced by vulnerability as cyber warfare becomes increasingly common. Due to the fact that cyberwarfare is not currently regulated under international law, the difficulty in attributing the attacks to any specific nation or organisation, and assuming that no lives were lost as a result, no state could justifiably authorise military retaliation in response to cyber assaults. Moreover, states with mid-sized or small militaries might not have any viable offensive kinetic options against suspected state organised cyber aggression. Consequently, small nations like Singapore should not neglect to build or shore up their online and IT protection frameworks and infrastructure as all societies becomes more dependent on secure cyber environments in the 4thIR.

Finally, the analysis returns to the physical dimension with drone warfare and genetic engineering. Addressing the former, the combination of machine learning, AI, advanced sensors and robotics brought about by the 4thIR brings autonomous combat drones out of science fiction into military reality, enabling the smaller militaries of the future to transcend manpower limitations and deploy more forces, albeit of the drone/robot rather than human variety. Conversely, if drones are given a freedom to deploy lethal force and are issued with unethical mission directives, they would be an excellent tool for rogue regimes or terrorists to do their dirty work. Just as with chemical, biological and nuclear weapons, autonomous combat drones also need to be regulated by international treaty to limit their use, proliferation and destructive potential.

As for genetic engineering, it has the potential to give any state mastering its safe use a massive advantage over others who have to rely on nature for the quality of their human endowments. Indeed, even basic DNA editing applied widely and hopefully affordably across entire populations to drastically reduce the rate of genetic impairments like eczema, asthma, mental retardation, Down syndrome, autism and other chronic conditions requiring lifelong remediative care, could indirectly facilitate military strength by reducing national healthcare costs, leaving more funds for the armed forces, along with strengthening the pool of healthy potential recruits.[11] But if analysis is confined to gene editing that bestows augmented physical and mental traits and has a rapidly realisable effect on armed forces unit capability, the cost per DNA rebuilt individual would be prohibitive, which implies that middle or small powers could only afford relatively fewer numbers of personnel operating at the frontiers of human potential. Ultimately, this limits the impact that such “boosted” service members can have on aggregate military potential. On the other hand, the downside of genetically enhanced soldiers falling victim to adversary radicalisation, thereby going rogue, or selling their services as mercenaries after retirement, creates a comparatively more disruptive effect on smaller states and their weaker militaries, as compared to larger nations with more military muscle, because the former has fewer gene modified national security personnel to rein in those ‘bad apples and loose cannons’.

[11] The writer thanks Major Mohammed Andyhardy of the Guards Formation, Republic of Singapore Army for his ideas regarding the indirect military utility of genetic engineering.

Conclusion

Focusing on the analytical snapshot of the 4thIR's military influences vis-à-vis personnel, intelligence, logistics and operational concerns provided by this paper, it is safe to say that mid-sized and smaller armed forces will largely benefit from the industrial upheaval and introduction of cutting-edge technologies like artificial intelligence, autonomous supply vehicles, field portable 3D printing and renewable solar energy.

Concerning other developments like encrypted smartphone communications, mobile internet access, and with the ubiquity of computer networks in the government, military and even vital public services, these arguably create a mixed bag of some helpful outcomes (facilitating troop mobilisation) but incur more than their fair share of threats (terror attacks directed from the darknet) and vulnerabilities (constant risk of cyberwarfare).

As for advancements of the 4thIR which transform the military's job but cause equal anxiety to national security planners, both combat drones and genetically enhanced soldiers have the potential to serve as excellent force multipliers for smaller armed forces, enabling them to accomplish missions more effectively whilst deploying less manpower. Conversely, the dark side of drone usage and DNA modified commandos involves their use for war crimes or political/religious violence and being radicalised or hired by violent organisations respectively.

All factors considered and depending on perceptions, the 4thIR can be taken to be a complicating development that both hinders and facilitates the work of smaller militaries in equal measure, or marginally benefits their operations in the next few decades to come. Inasmuch as small and mid-sized armed forces do not have the resource base to implement the 4thIR's technological marvels on a wide scale, thereby maximising their benefits and making negative side outcomes more tolerable, it would still behoove non-great states like Singapore to ensure that their defence ministries remain open to change, be willing to embrace new technology and their military implications, and be receptive to any needed changes to established doctrine in order to accommodate the latest developments from the 4thIR. Even though senior commanders and veteran policymakers are likely to be creatures of habit and tradition, they need to be firmly reminded that failure to stay ahead of the curve and incorporate the 4thIR's advancements into their force development plans will result in their nation's defence capabilities being overshadowed by the offensive strategies of more flexible state adversaries and adaptable terrorist groups.

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