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Editorial

Since our independence in 1965, Singapore has come a long way. We have built ourselves up to become a strong and independent nation with a cohesive society committed to protect and defend our home and way of life. However, the external environment has changed – it has become increasingly volatile and more complex. The security challenge not just to Singapore but globally is something that we have to be cognisant of and be alert to. Terrorist threats like the suicide bombings in Brussels, the bomb and gun attacks in Jakarta, unconventional threats like piracy as well as the on-going disputes in the South China Sea—these are all stark reminders of the perils that can affect and impact us. Let us never take our present peace and stability for granted. We must remember that a strong defence force is vital for our security and independence. As Chief of Defence Force, MG Perry Lim said, "The strategic vulnerabilities of a small nation will always remain unchanged, and a strong SAF is the ultimate guarantor for Singapore's peace and security."[1]

In this issue of Pointer, we offer a varied list of essays which include a discussion on our deterrence measures and the development of the SAF from 1st generation army to a highly sophisticated 3rd generation fighting force, as well as an analysis on the maritime security challenges faced by countries in the Indo-Pacific region. There is also a discourse about how a state can 'strategically bridge' its political goals with its military decision planning. Other topics include a presentation on 3D printing as an innovative and revolutionary piece of technology with potentially significant applications for the military, an exploration of the Lanchester Square Law[2] and its links to the concept of Relative Combat Power (RCP) and finally, an examination of cognitive biases and how it might affect military decisions at the strategic and operational levels.

In the essay, 'The Strategy Bridge: Linking the Tactical and Operational Battles to the National Interests', LTC Eng Cheng Heng, contends that in order to effectively achieve its political goals, a state has to strategically bridge its political goals with its military decision planning. He discusses some of these 'strategy bridges' employed throughout history and examines case studies of how various wartime figureheads have aligned their states' overall political goals with its military decision, with varying levels of success. Through these case studies, he notes that military tactical and operational level victories do not necessarily equate to a nation's political victory.

MAJ Lim Han Wei's essay is entitled, 'Code for Unplanned Encounters at Sea and Maritime Stability in the Indo-Pacific'. In his essay, MAJ Lim talks about the maritime security challenges that are faced by countries in the Indo-Pacific region and discusses the possible policy measures that can be put in place to help ease tensions between countries involved in territorial disputes. Due to the benefits that the Indo-Pacific region presents, it is thus subjected to maritime security threats. If left unattended, the tensions have the potential to escalate into great conflicts. Throughout the essay, MAJ Lim maintains the stand that despite the interests of individual countries, there is a need for everyone to come to a common consensus and work together so as to maintain peace and stability in the region.

The essay, 'Is the SAF's Defence Posture Still Relevant as the Nature of Warfare Continues to Evolve?' is written by MAJ Bernard Tay. According to MAJ Tay, in the years following her independence, Singapore has had to build up a credible military force to deter and defend threats to its security, territorial integrity and sovereignty. He explains the various changes of our deterrence measures and the evolutionary stages of our SAF—from a 1st generation army to the highly sophisticated 3rd generation fighting force we know today. In his essay, MAJ Tay also aims to evaluate how the SAF's defence policies have transformed over the years to better adapt to the recent unconventional threats our nation faces such as cyber-attacks and transnational terrorist attacks. Finally, he suggests how the SAF can better collaborate with Homefront agencies, government ministries and international bodies to be more effective in deterring such threats, as well as sustaining a stronger and more credible deterrence force.

In their essay, '3D Printing – Revolutionising Military Operations', ME5 Calvin Seah Ser Thong and ME4 Choo Wei En, claim that 3D printing has proven to be an innovative and revolutionary part of technology with potentially significant applications for the military. In this essay, the authors explore the technology, applicability and challenges before proposing a framework for our army to undertake 3D printing. Firstly, they provide a brief overview of the technology behind the printing process and the various printing methods. They then highlight the numerous possible military applications of 3D printing, including the production of military equipment both during peacetime and on the battlefield, for immediate use. Other uses include protective armour for soldiers, prosthetics, surveillance tools and even food. However, given the nascent stage of technology, the authors highlight that there are challenges that need to be addressed, such as Intellectual Property rights, liability, occupational health and safety, cost and quality standards. The authors conclude by suggesting a framework to mitigate these challenges, which includes creating a task force to study the feasibility of this technology and disseminating 3D printing-related knowledge. In the authors' opinion, there is no doubt that the prudent use of 3D printing technology will yield innumerable benefits for our army.

In our Tech Edge section, we are featuring the essay, 'The Lanchester Square Law: Its Implications for Force Structure and Force Preparation of Singapore's Operationally-Ready Soldiers' by LTA(NS) Philip Chan. In this essay, LTA(NS) Chan explores the Lanchester Square Law and links it to the concept of RCP, seeking to understand whether the quality of soldiers matters more than their quantity. LTA(NS) Chan shows the implications of the Lanchester Square Law for tactics in combat, by exploring test-cases of battles between a seven-man and ten-man section. Next, he explains how Admiral Lord Nelson's tactics at the Battle of Trafalgar were in fact an application of the Lanchester Square Law. He feels that the importance of numbers has implications for the force structure of our army and the advantage of an opponent's numbers needs to be compensated by a significant increase in the quality of our own forces. In his opinion, our commanders should maintain a high baseline of quality in peacetime, as Singapore depends heavily on both the quantity and quality of our Operationally-Ready servicemen. Only then can the SAF harness the advantages of quantity and quality, enhanced by detailed and coordinated planning, to secure a swift and decisive victory over any aggressor.

Our View Point essay entitled, 'Cognitive Biases: The Root of Irrationality in Military Decision-Making' is written by CPT Chen Jing Kai. In this essay, CPT Chen explores the different types of military decision-making by operational staff and how it might affect the rationality of their assessment of the current situation He then provides examples for each different type of bias which include overconfidence bias, confirmation bias, disconfirmation bias, availability bias, sunk cost fallacy and anchoring bias and proposes ways to mitigate such biases, so that the SAF can be more accurate in its assessments and thus make better decisions. CPT Chen highlights that in combination with contextual factors, cognitive biases have been shown to result in starkly inaccurate assessments and therefore poor military decisions at the strategic and operational levels. He concludes that the SAF needs to be cognisant of these biases and to implement strategies to counteract them.

The POINTER Editorial Team

ENDNOTES

1. http://www.mindef.gov.sg/imindef/press_room/official_releases/sp/2016/26may16_speech.html#.V1eibjWGPIU
2. https://en.wikipedia.org/wiki/Lanchester%27s_laws#Lanchester.27s_Square_Law

   With firearms engaging each other directly with aimed shooting from a distance, a fighting force can attack multiple targets and can receive fire from multiple directions. The rate of attrition now depends only on the number of weapons shooting. Lanchester determined that the power of such a force is proportional not to the number of units it has, but to the square of the number of units. This is known as Lanchester's Square Law.

The Strategy Bridge: Linking the Tactical and Operational Battles to the National Interests

by **LTC Eng Cheng Heng**

Abstract:

In this essay, the author contends that in order to effectively achieve its political goals, a state has to strategically bridge its political goals with its military decision planning. He discusses some of these 'strategy bridges' employed throughout history and examines case studies of how various wartime figureheads have aligned their states' overall political goals with its military decision, with varying levels of success. Through these case studies, he notes that military tactical and operational level victories do not necessarily equate to a nation's political victory.

Keywords: Strategy; Decision making; Perception; Tactical; Operational

INTRODUCTION

"War is not a mere act of policy but a true political instrument, a continuation of political activity by other means."[1] Clausewitz's enduring dictum on the use of the military instrument in the service of political goals encapsulates the essence of this essay as it aims to investigate strategy. It is a generally accepted truth that strategy is the bridge linking the political goals (of a state) to the military instrument of statecraft such that its ability to wage war can be brought into the appropriate service of these goals that serve to further and/or sustain national interests.[2] It is also true that the military instrument of statecraft is but one of the larger arsenal of tools that a state has at its disposal to pursue its national interests and accompanying political goals.[3]

The frequency or the priority with which the military instrument is selected as the tool of choice is dependent on a variety of factors. However, there is no denying that even if it is not wielded, the strength of the military and its availability in the arsenal have a large influence on the effectiveness of the other instruments of statecraft.[4] It is this 'centrality' of the military instrument in relation to political goals that the subject of strategy is important. Correctly conceived strategy enables the efficient use of the military towards these political ends, be it for the purposes of waging war or coercion, while incorrectly conceived strategy makes the outcome of any war or coercion meaningless even if the military wins tactical or operational victories. This articulation of the strategy bridge brings to mind Colin Gray's view that "The strategist does not strive to win a war tactically. His mission is not to pile up a succession of tactical or even operational level victories. Rather, it is his function to so direct his disparate assets such that their total net effect contributes positively to the securing of whatever it is that policy demands."[5]

This essay concurs with Gray's proposition of the strategist's role. However, it will qualify that while the accumulation of tactical or operational victories

by the strategist might not be critical to the political outcome, the achievement of certain permutations and the quantity of tactical or operational victories are elements of a successful strategy—otherwise there would not be much point in employing the military instrument if there were no intentions of enjoying any shred of success. The caveat is that the impact these victories have must be aligned with the greater political goal(s) that exist at the grand strategic level. Hence, it is also the strategist's role to monitor the progress of the tactical/operational elements of strategy and their alignment towards the achievement of political goals and adjust the strategy accordingly to sustain the alignment amidst the constant shifts between the tactical/operational and grand strategic levels of strategy. This is the crux of Gray's point about strategy involving the constant interaction between ideas, through experience and scholarship that shape behaviour in the real world.[6]

FRAMEWORK

The essay will begin by establishing the construct of the strategy bridge using Edward Luttwak's *Levels of Strategy*, Gray's *Dimensions of Strategy* and Harry Summer's *Concept of Trinitarian War*, derived from Clausewitz's Trinity before using this construct to illustrate that the strategist's role also includes the need to monitor the construct of the strategy bridge and adjust for the dynamic nature of the bridge's components. This would ensure the alignment between the tactical or operational and the grand strategic parts of the bridge.[7]

Several case studies will be referred to across different time periods in which the nature of war has changed significantly: Alexander the Great and his conquest of Persia, Napoleon in the Napoleonic Wars, Germany and Japan in World War Two (WWII) and the United States (US) in WWII, Vietnam War and the First and Second Gulf Wars with Iraq. The milestones of the eras that these cases span are the French Revolution, World War Two and the current time period. I will elaborate on the significance of the periods between these milestones subsequently.

The strategy bridge is thus constructed with multiple dimensions existing in a hierarchical order of separate levels that revolve around the relationship between the nation (the people), the military (the executors of the use of force) and the government (the political institutions of state). The ultimate aim of the bridge is to link the use of force or threat of it—including making the necessary preparations for war—to the achievement of political goals as defined by the government in order to serve the nation's interests.

THE CONSTRUCT OF THE STRATEGY BRIDGE

Luttwak lays out strategy as comprising of five separate levels in a hierarchical order within the grand strategic level (where the military outcomes are viewed in combination with other aspects of statecraft) being the pinnacle.[8] The four levels subordinate to this, which deal exclusively with the military instrument are, in descending order: the theatre level, operational level, tactical level and technical level. This is not to say however, that the levels interact via a top-down approach, but rather, in a two-way process with the consequences at each level affecting the entire chain in some way, in what Luttwak terms the vertical dimension (across the levels) and the horizontal dimension (within

each level).[9] The tactical level concerns actions on the battlefield and the deployment of forces. The operational level links the tactical battles with the theatre strategy and through it, to the larger aims at the grand strategic level.

Gray lists seventeen separate dimensions of strategy with the dimensions grouped into three general categories. People and politics is the first category and it comprises people, society, culture, politics and ethics.[10] The second category is preparation for war. It comprises economics and logistics, organisation, military administration, information and intelligence, strategic theory and doctrine and technology.[11] The final category, war proper comprises military operations, command, geography, adversary and lastly, friction, chance and uncertainty.[12]

Summers interpreted Clausewitz to mean that strategy is contingent on maintaining the balance of interaction between the triad of the people, the armed forces and the state.[13]

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A BRIEF HISTORY OF THE NATURE OF WAR AND ITS IMPACT ON STRATEGY

A point to note is that the above conceptions of the strategy bridge describe the nature of strategy post-Clausewitz. A key reason for the selection of such a conception is the fact that this is the foundation upon which modern strategy is examined. Although a case study before Clausewitz, i.e. Alexander the Great is cited in the essay, the purpose of its inclusion is meant to highlight the link between the tactical/

Painting depicting the Departure of the Conscripts of 1807 by Louis-Léopold Boilly.

operational level of strategy and the political level. While the battlefields and technology might differ in the periods that the case studies exist, the act of war itself has remained a constant throughout time. Clausewitz's treatise was based largely upon his experiences in the Napoleonic Wars. The Napoleonic Wars were themselves a landmark in strategic theory with the concept of the *Levée en masse* (mass conscription) brought about by the French Revolution, thus introducing a radical paradigm shift that accounted for the people of the state as having a stake in the triad that Summers described. Prior to the French Revolution, "war was still an affair for governments alone, and the people's role was simply that of an instrument... the executive... represented the state in its foreign relations... the peoples' part had been extinguished... War thus became solely the concern of the government to the extent that governments parted company with their peoples and behaved as if they were themselves the state."[15]

In the period following the French Revolution, the character of nations that had previously been based on dynastic rule now changed towards national democracies. Now, the interests of the people as a community of the state were what nations used to set political goals and harness the military instrument to pursue.[16] Coupled with the technological advances of the Industrial Revolution, the doctrine of mobilising mass armies to seek a decisive battle following Napoleon's example nudged the world towards the concept of what became known as 'Total War', as envisioned by Ludendorff, and culminating with WWII.[17] The apogee of this conflict was the atomic bombing of Hiroshima and Nagasaki. The scale of destruction and damage that the conflict wrought made the price of 'decisive victory' too high to pay and ushered in a new era of limited warfare.[18]

The post-WWII era saw people's restrained appetites for war in the aftermath of the massive scale of destruction juxtaposed against the pursuit of their interests as part of a nation by their governments through the continued use of the military instrument, amongst others. The evolution of the media—particularly what became popularly known as 'The CNN Effect'—in bringing the realities and information of the battlefield right in the faces of people introduced a new element to the already complex relationship between Summer's triumvirate and the levels and dimensions of strategy. The Vietnam War, also known as the TV War where the results of the war were first broadcasted to peoples' living rooms, and the First Gulf War, where CNN provided total televised coverage of the conflict, characterised this new information era and impacted how people perceived the state's usage of the military instrument.

ALEXANDER THE GREAT

Two keys traits characterised Alexander's successful conquests: his ability to secure the position of Macedonia within the League of Corinth, and thereafter, his masterful defeat of the Persian Empire that was far superior to Macedonia in terms of size and scale. While Alexander was famous for his skill as a warrior on the battlefield, he was less well known for his astute use of grand strategy to complement the military victories that enhanced his legend in order to secure his gains and build his own empire.

A fundamental enabler of his success was his ability to harmonise the levels of strategy. One military episode that underlines this was his campaign to neutralise the powerful Persian Navy whom he had identified as an enemy Centre of Gravity for its ability to invade Greece and hence, threaten the League of Corinth and Macedonia's position as the League's hegemon.[19]

While Alexander was famous for his skill as a warrior on the battlefield, he was less well known for his astute use of grand strategy to complement the military victories that enhanced his legend in order to secure his gains and build his own empire.

Alexander demonstrated sound application of the dimensions of strategy by leveraging on the strength of his land forces to approach the Persian Naval Campaign instead of pitting his Navy against the well-trained Persian fleet at sea.[20] His forces won a series of tactical battles to capture Persian ports and naval bases, thus removing the Persian Navy's ability to provide logistic support to sustain their operations. Alexander's tactical and operational success prompted capitulations from the Persian-allied Phoenicians who switched their allegiances to Alexander. The neutralisation of Persian naval power secured Greece from a Persian invasion and strengthened Macedonia's position in the League, thus enabling Alexander an opportunity to consolidate his gains. This episode clearly underlined how Alexander's tactical and operational victories contributed towards his empire building. Although it is arguable that he might have found other tactical means to deny the Persian Navy their logistics support had he lost the

The Kingdom of Macedon in 336 BC, where Alexander battled the Persian Navy.

battles to capture their ports, such as instigating other states to defeat the Persians or using his own fleet to defeat the Persians at sea, it is doubtful that such alternatives were feasible considering the relative strength of the Persian Navy to the Macedonian fleet or the Persian Army to the other states within its empire.

NAPOLEON'S FRANCE, HITLER'S GERMANY AND HIROHITO'S JAPAN

The common thread that binds the French, German and Japanese together were their armed forces' decisive score of tactical and operational level triumphs in each of the wars their countries fought, and also the eventual strategic defeat that they suffered despite these victories.

The painting "Le Trophee", by Edouard Detaille, depicting a French Dragoon with a captured Prussian flag at the Battle of Jena-Auerstedt.

Napoleon's rout of the Prussians at Jena and Auerstadt are perhaps two of the most famous battles that headline his triumphs while the failure of his Russian adventure and the subsequent annihilation of the French army at Waterloo characterised his greatest failures as a strategist. The tactical and operational superiority of Napoleon's army in seeking decisive battle, using the speed of manoeuvre and concentrating forces at the decisive point was the inspiration for Clausewitz's theory of victory in war. The German concept of Blitzkrieg similarly underpinned early German successes in WWII and triggered a rise of operational theories about manoeuvre warfare. However, this foray into Russia dissolved the non-alliance pact between Hitler and Stalin and, coupled with the American entry into the war, began to turn the tides of strategy in favour of the Allies. All the German military's tactical and operational victories from then merely delayed their inevitable defeat. Similarly, the Japanese army demonstrated their tactical and operational superiorities over the British in their conquest of Southeast Asia and also their devastating attack on the American fleet at Pearl Harbour. Pearl Harbour proved to be a double-edged sword as it brought the mighty American war machine into the arena. Although the Japanese, like the Germans, managed to continue enjoying tactical and operational successes in the Pacific, it would eventually be unable to stop the tide turning, culminating in the atomic bombing of Hiroshima and Nagasaki, leading to the Japanese surrender.

In each instance, the French, German and Japanese went beyond what Clausewitz calls the culminating point of victory. Each stretched themselves beyond their tactical and operational capabilities, resulting in failure at the grand strategic level when their

opponents banded together to defeat them. Napoleon's defeat at Waterloo should not be looked at in isolation, rather, it was his ill-advised campaign to invade Russia, coupled with the attrition of the French Army in Russia and further exacerbated by his losses in the Spanish counter-insurgency that laid the foundations for his defeat at Waterloo. At Waterloo, when the combined Prussian and British forces outmatched Napoleon's army, he was unable to accept a limited defeat and preserve his army thereafter and, that led to a crippling of the French state's military instrument in its entirety.[21] Similarly in WWII, the rapid and decisive tactical and operational level victories that the Germans and Japanese had accumulated were unable to subdue the British or Americans and achieve the political objective to prevent them from entering into the war to interfere with the Axis' campaign of conquest. This eventually changed the nature of the war into one of attrition where, considering the huge materiel disadvantage the Germans and Japanese suffered, their defeat was only a matter of time in coming.[22]

THE US IN WWII, VIETNAM AND IRAQ

The United States (US) armed forces since WWII is generally considered to be the most powerful military force of the modern world with its only close competitor being the Soviet Union during the Cold War. It helped the Allies to turn the tide in both World Wars and blitzed the opposition off the battlefield in the Vietnam and the two Gulf Wars. Unlike the French, German or Japanese in the previous case study, they certainly were not confronted by a superior force, yet Vietnam was considered a failure, and until recently, so was the Second Gulf War although the jury is still out on the outcome. Only WWII and the First Gulf War could be considered to be anywhere near an overall success.

The title of the introductory chapter in Summer's analysis of the Vietnam War aptly reflects the overall view of the American scorecard: Tactical Victory, Strategic Defeat.[23] The tactical/operational victories in Vietnam were further underlined by the conventional war criteria of the kill ratio and body count that General Westmoreland, the American commander at the time used, to proclaim that America was winning the war.[24] This definition did not correspond with the perception of victory of the era. The American population did not view the finality of a Communist Vietnam with the same strategic lens as a German-dominated Europe or a Japanese-dominated Asia.[25] This coloured their perception of what the strategic aims of the war should be and caused a loss of public

The September 11 attack was one of the factors that helped gain public support for the Second Gulf War.

support for the war effort as the North Vietnamese dug in and American casualties climbed, albeit the number of Americans killed to the enemy were much lower. By contrast, the tactical and operational outcomes in WWII and the First Gulf War were aligned with the strategic aims as perceived by the public; a need to drive the occupiers out of Kuwait and thereafter, the victorious return of the American troops home.

During the Second Gulf War, one of the strategic aims of liberating Iraq from the oppressive regime of Saddam Hussein (at least the one that was used to gain public support) was certainly helped by the political capital that the September 11th attacks provided.[26] The success of the Shock and Awe doctrine resulted in a level of tactical and operational dominance and resulted in the defeat of Saddam Hussein within twenty-one days. American troops were welcomed in the streets of Iraq as liberators. The initial euphoria in meeting the political goal of deposing Saddam Hussein was not to last however, as the sudden power vacuum gave rise to a counter-insurgency campaign against the remnants of the former ruling Ba'ath party, resulting in a war of attrition against insurgents that were content to dig in while American casualties mounted and eroded the public support back home.[27] It was not until General David Petraeus introduced 'The Surge' strategy to deal with the counter-insurgency that the US was able to re-define the criteria for strategic victory—by regaining public support and moving the American military effort in a new direction to deal with a counter-insurgency campaign instead of a conventional war.

ANALYSIS

In the case of Alexander the Great, he led in an era where he embodied the state, the armed forces and his people. He was able to exert a high level of control over all the levels of strategy (except for the technical level). Hence, it was relatively easier for him to find success compared to the nations cited in the later examples.[28]

In the case of France, Germany and Japan, although the people in Summers' triumvirate had a larger effect on the eventual strategic outcome, the militant nature of the state meant that it was enmeshed with the armed forces. As such, the level of control that the governments or singular figureheads (Napoleon, Hitler or Hirohito) could exert over the levels of strategy, was also significant. Their failure stemmed from an inability to navigate the grand strategic level. Firstly, they did not influence the political outcomes relative to their opponents in their favour. Secondly, they were unable to recognise the unrealistic odds this would impose at the tactical/operational levels and adjust their national interests to accept a compromise or, in the words of Gray, lose the war "if not gracefully at least in such a way that the successful enemy is powerfully motivated to settle for an advantageous, rather than a triumphantly punitive, peace."[29]

With the US, the democratic character of the country meant that the people, in the form of the voting electorate, exerted a significant effect on the interaction of the triumvirate. The civil-military relations between the civilian political office-holders representing the state and the armed forces added to the complexity of this interaction. This also meant that it was essential for the military to communicate clearly with the political leadership to determine the best strategy considering what it could or should achieve at the tactical/operational levels and for the political leadership at the same time to find the balance between what the military

could achieve and the public opinion of the people to craft the appropriate policy goals or grand strategic objectives. The relatively more complex interaction in the triumvirate and different entities controlling the various levels of strategy muddied the effectiveness of tactical or operational victories toward the desired political outcomes.

The strategist needs to monitor all aspects of the triad's interaction and discern how it affects the political outcomes.

CONCLUSION

In closing, the case studies cited across the varying time periods have illustrated how the different levels and dimensions of strategy together with the interactions of Summer's triumvirate affected the eventual political outcome that is the product of the entire strategy machinery. The case studies have demonstrated that tactical and operational outcomes matter (because they contribute to the political/grand strategic aim). It is a matter of whether the correct policy goals to support the appropriate national interest have been formulated from the combined inputs of the triumvirate and whether the tactical and operational criteria for victory are correctly aligned. Depending on the complexity of the triumvirate, this would affect the amount of unity over the controls of the levels of strategy and their various dimensions. The strategist needs to monitor all aspects of the triad's interaction and discern how it affects the political outcomes. He must make adjustments to maintain the alignment of the tactical and operational levels of strategy with the grand strategic level if he senses shifts in the national interests or political goals that could potentially disturb this alignment so that the end product of political outcome is not compromised.

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Code for Unplanned Encounters at Sea and Maritime Stability in the Indo-Pacific

by **MAJ Lim Han Wei**

Abstract:

In this essay, the author talks about the maritime security challenges that are faced by countries in the Indo-Pacific region, as well as the possible policy measures that can be put in place to help ease tensions between countries involved in territorial disputes. Due to the benefits that the Indo-Pacific region presents, it is thus subjected to maritime security threats. If left unattended, the tensions have the potential to escalate into great conflicts. Throughout the essay, the author maintains the stand that despite the interests of individual countries, there is a need for everyone to come to a common consensus and work together so as to maintain peace and stability in the region.

Keywords: Tensions; Territorial Disputes; Maritime Security Threats; Common Consensus; Peace and Stability

INTRODUCTION

The Indo-Pacific region, spanning the Western Pacific Ocean to India, has emerged as a key geostrategic region in the 21st century for global commerce, energy supplies and economic investments. It encompasses close to half of the world's population, numerous island chains and some of the world's most important sea-lanes for global trade, including the Strait of Malacca and the South China Sea (SCS). More than half of the Indo-Pacific states' population live along the coast and depend on its oceans and seas economically, such as fishing, tourism and energy resources. At the same time, these maritime zones present a host of dangers that threaten the security of states and economic livelihood of the local population, ranging from territorial disputes and transnational crimes to environmental pollution.[1] These present complex maritime security challenges for the region's naval forces and any successful responses to such threats require international cooperation as they are transnational in nature and do not respect maritime boundaries.

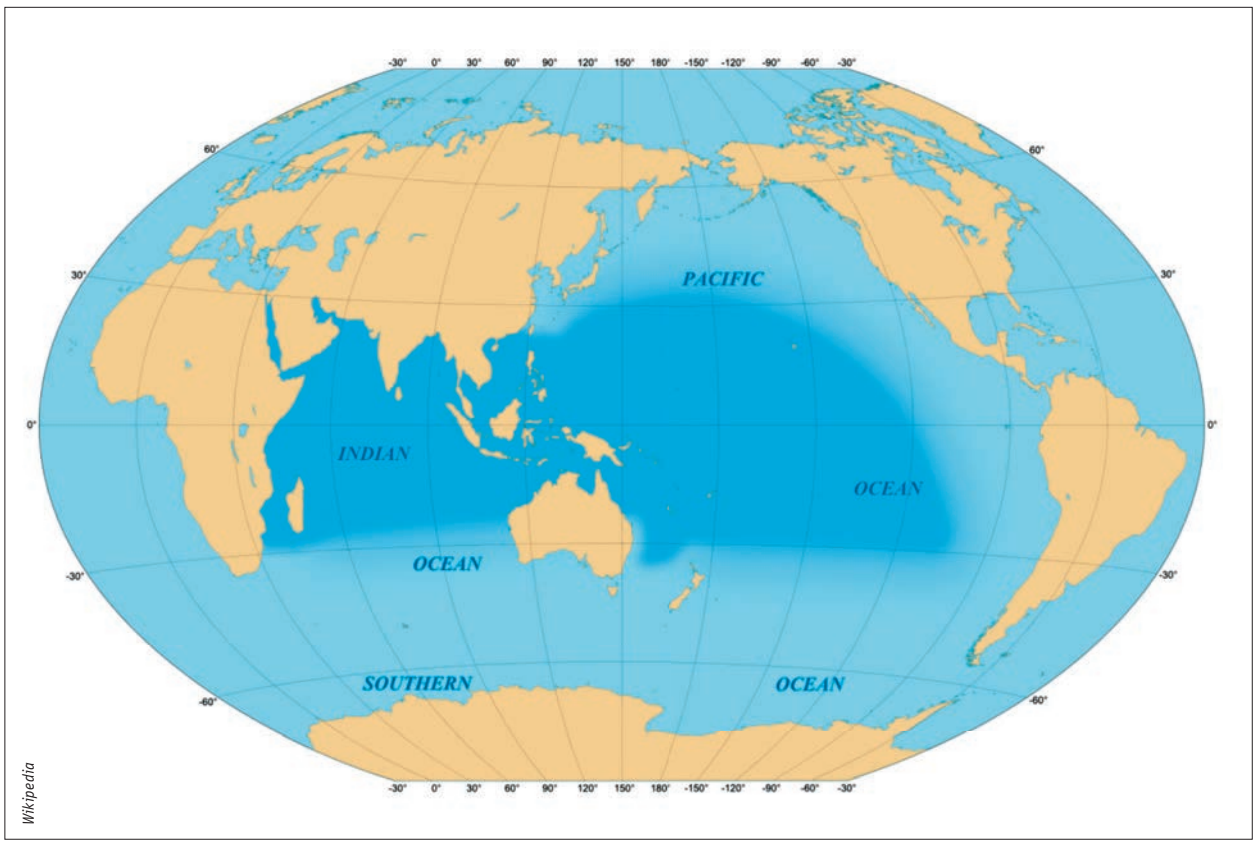
This essay seeks to examine the challenges of maritime security and stability in the Indo-Pacific region. As the Indo-Pacific region is a vast area, it is necessary to scope this paper's analysis to the context of maritime tensions and territorial disputes in Northeast and Southeast Asia since they present the greatest potential for conflict escalation and hence pose the largest threats to maritime security and stability in the Indo-Pacific region. This essay contends that while China's agreement to the Code for Unplanned Encounters at Sea (CUES) is a positive step forward in reducing the prospects for maritime conflicts, this measure alone is insufficient in ensuring that maritime stability and security will prevail in the region. This argument will be elucidated via analysing the causes and drivers behind maritime tensions and

disputes in the region. The relevance and utility of the CUES agreement and its principles will be scrutinised, with a view to identifying its strengths and weaknesses in de-escalating such disputes and conflicts. The essay will then conclude by examining a range of policy options that can be employed to further ease inter-state tensions and de-escalate the risks of maritime conflicts in the Indo-Pacific region.

MARITIME TENSIONS IN INDO-PACIFIC REGION

This section will provide an analysis of the factors and drivers behind maritime tensions in the region. Northeast and Southeast Asia are characterised by historical animosities and complex geopolitical dynamics between states. The rise of China as an economic and military power, lingering disputes over maritime territories and United States (US) rebalancing towards Asia all point to the sea as the key to continued security and stability.[2] China is currently embroiled in maritime disagreements with Japan and South Korea in the East China Sea (ECS), due to differing interpretations in defining their Exclusive Economic Zones (EEZs) based on the 1982 United Nations Convention on the Law of the Sea (UNCLOS). This same issue arises in the SCS and China is similarly involved in several maritime disputes with Southeast Asian nations over the Spratly and Paracel Islands and its 'nine-dash line' claim.[3] There are three main factors contributing to these maritime disputes.

Firstly, the rise of China has caused relative powers between states to be shifted significantly in the past decades. Notably, China's defence strategy has shifted from one of continental defence to forward active



The areas covered by the Indo-Pacific biogeograhic region.

defence, resulting in a resurgent People's Liberation Army Navy (PLAN) that aspires to control the waters out to the 'first island chain'.[4] This has led to China's growing aggressiveness in asserting control over her maritime spaces and resulted in increased suspicions among states on China's hegemonic intentions in the region. Consequently, the power balance has evolved from Japan's predominance of China to a condition of parity in the ECS and from parity to China's predominance over Association of Southeast Asian Nations (ASEAN) claimants in the SCS.[5]

More than half of the Indo-Pacific states' population live along the coast and depend on its oceans and seas economically, such as fishing, tourism and energy resources.

Secondly, both regions are marred by unresolved historical baggage and national interests to pursue 'historical claims' due to strong nationalist sentiments. Japan and China have traditionally possessed deep-seated hatred towards each other due to past clashes in the Sino-Japanese War and World War Two (WWII), while most ASEAN countries have previously experienced occupation under colonial powers that left a deep scar in their histories. Hence, any explicit actions to lay claim to disputed territories will invariably spark off nationalistic sentiments in claimant states and cause unnecessary escalation in tensions. China's recent oil rig deployment in the disputed Paracel Islands is a case in point, having stroked nationalistic fervour in both China and Vietnam, resulting in violent protests.[6]

Thirdly, after UNCLOS III established the EEZ regime, 87% of the world's known hydrocarbon fields were placed under the coastal states' jurisdiction. As the disputed territories and their maritime delimitations are potentially rich in economic resources such as energy and fishery, states are motivated to maximise their maritime zone claims for economic exploitation, either through EEZ or extended continental shelf claims.[7] This has resulted in numerous overlapping claims, especially in the SCS.

CODE FOR UNPLANNED ENCOUNTERS AT SEA

This section will scrutinise the relevance and utility of CUES in de-escalating maritime disputes and contributing to regional stability and security. At the 2014 Western Pacific Naval Symposium (WPNS) in Qingdao, 25 navies, including the United States Navy (USN) and PLAN, agreed to adopt CUES as a means of communications between naval assets at sea, in an attempt to quell existing maritime tensions. This code recommends safety procedures, communications plan and manoeuvring instructions to improve communications between naval assets in the event of unplanned encounters at sea.[8] Such an agreement serves to reduce the risks of strategic miscalculations that could lead to potential conflicts, such as the near-miss in December 2013 between a PLAN warship, supporting China's aircraft carrier *Liaoning*, and USS *Cowpens*, which was forced to alter its course abruptly to avoid a collision.[9] CUES has been hailed as a substantial move to enhance maritime safety and communications, with Admiral Wu Shengli, PLAN Commander, praising it as a "milestone document," and Admiral Harry Harris, USN Pacific Fleet Commander, calling CUES as "an important step forward to reduce tension on the sea in the region."[10] CUES is also a significant achievement for WPNS, considering that the idea was mooted over 10 years ago and China had initially expressed opposition to CUES at the 2012 WPNS, objecting to the usage of the term 'code' as implying legally binding and English as the primary language of communications for CUES.[11] China's turnaround and adoption of CUES demonstrated

PLAN's determination to strengthen cooperation with her partner navies and more importantly, signalled China's willingness to work with the global maritime community on internationally recognised standards for the peaceful conduct of maritime activities.[12] Besides warships, the inclusion of aircraft in CUES also offers potential for states to derive standardised rules and norms governing unplanned aircraft encounters in China's declared Air Defence Identification Zone (ADIZ) over ECS in November 2013.[13]

Despite its significance as a confidence-building measure, the signing of CUES marks only a baby step forward in enhancing maritime stability and security in the region. Several weaknesses exist within CUES that restrict it from fully carrying out its function of defusing inter-state maritime tensions in the region. Firstly, CUES only addressed communications between naval vessels and aircraft, but does not cover communications between maritime constabulary and 'white-hull' vessels, which have been increasingly deployed by states in disputed waters and EEZs for patrols and as a show of force.[14] A case in point is the recent involvement of over 100 Chinese and Vietnamese naval, maritime police and fishery ships in the tense stand-off over the Chinese oil-rig deployment in the Paracels.[15] It remains to be seen whether maritime constabulary vessels, such as those from the Chinese and Vietnamese Coast Guards, will adhere to CUES in such situations.

Secondly, CUES is a voluntary and non-binding agreement and its applicability seems to be limited to only the EEZs and high seas, but not territorial waters. This implies that naval vessels do not need to adhere to CUES when they are within 12 nautical miles of a disputed maritime territory, such as the Spratly islands in SCS or Senkaku/Diaoyu islands in ECS where China disputes their sovereignty with ASEAN claimants and Japan respectively. PLAN vessels can potentially argue that CUES does not apply since they are operating within territorial waters claimed by China.[16] The non-binding nature of the agreement also makes it weak in the eyes of international law and is probably the key reason for China's consent to it, knowing that it cannot be held accountable for PLAN's non-adherence to CUES in the ongoing territorial disputes. Vice-Admiral Xu Hongmeng alluded to this when he emphasised that CUES would not affect the conduct of Chinese ships in the disputed waters of ECS and SCS.[17] Thus, in such cases, China is likely to restrict the application of CUES only to cases where they have established bilateral talks with extra-regional navies not involved in the disputes.[18] This will hardly contribute towards the de-escalation of tensions in disputed waters.

Thirdly, CUES only recommends communications protocols for vessels in unplanned maritime encounters, but does not regulate their behaviour in any way, unlike the 1972 US-Soviet's Incidents At Sea Agreement (INCSEA). In addition to regulating communications between US and Soviet naval assets, INCSEA also specified for both sides not to engage in simulated attacks, to maintain a safe distance and avoid manoeuvres that would endanger or embarrass naval forces under surveillance.[19] An agreement that can regulate the behaviour of naval vessels will be more useful in defusing tensions at sea. As an example, Article III paragraph six of INCSEA stated for vessels to avoid pointing weapons at passing ships, which would have discouraged previous incidents, such as the lock-on of a Japanese warship and helicopter by Chinese fire-control radar in early 2013, from taking place.[20]

Finally, and perhaps most importantly, CUES fails to address the fundamental differences in US and China's interpretations of a state's legal rights within its EEZ.[21] During the decade-long UNCLOS negotiations, states agreed to establish EEZs as a specific legal regime under international law. This was a result of a compromise at UNCLOS III that conferred coastal states specific rights to regulate economic activities within their EEZs, but preserved the rights and freedoms of user states as laid out in the convention.[22] Rightly so, the US and most countries have emphasised the importance of freedom of navigation in the EEZs on the high seas, where permission to conduct military activities is not required from the coastal state. However, China and at least 30 states are challenging the status quo to interpret UNCLOS as conferring coastal states the right to regulate all EEZ activities and that permission to conduct military activities has to be explicitly obtained from the coastal state. China's stand on this is in line with her maritime strategy of Anti-Access/Area-Denial (A2/AD) and to deny its adversaries freedom of navigation and use of the sea.[23] As long as China continues to pursue this approach, any INCSEA-like agreement, CUES or the 1977 International Regulations for Preventing Collisions at Sea (COLREGS) can only offer a partial solution to defusing maritime tensions in the EEZs and on the high seas.

POLICY MEASURES TO DEFUSE INTER-STATE MARITIME TENSIONS

The prospects of a maritime dispute escalating into conflict in the Indo-Pacific region appear daunting. However, this can potentially offer more opportunities than threats. This section will provide recommendations on policy measures that can be employed to further defuse or contain inter-state maritime tensions in the region, using the broad Diplomatic-Military-Economic dimensions as a framework.

Diplomatic Measures

While regional states have expressed willingness to de-escalate tensions built up by recent incidents in SCS during the Shangri-La Dialogue (SLD) in June

A luncheon for ministers and representatives from various countries during the 2014 Shangri-La Dialogue.

2014, this is currently hampered by a lack of strategic trust among states. In order to overcome this, states will need to learn to build mutual trust through instituting resilient confidence-building mechanisms that will allow common consensus and political will to be forged.[24] There are four broad diplomatic measures that can help to achieve this. Firstly, states need to create avenues to have frank and open dialogues and to establish a clear understanding of one another's security challenges. These have the effect of promoting transparency and predictability, which is crucial in preventing strategic miscalculations. States should leverage on multilateral platforms, such as the SLD, WPNS and ASEAN Defence Ministers Meeting-Plus (ADMM-Plus) frameworks to strengthen mutual trust, as well as security and defence cooperation.[25] These will pave the way forward for states to work together to resolve security challenges and act as springboards for the discussion of risk-reduction measures to defuse tensions generated by maritime-related disputes.

Increased dialogue and expanded naval cooperation between US, Chinese and regional militaries can go a long way towards soothing inter-state tensions.

Secondly, the implementation of a binding code of conduct between China and ASEAN countries will aid in easing tensions involving SCS territorial disputes. While the parties have previously agreed to build confidence and reduce risks through adopting the 2002 Declaration on the Conduct (DOC) of Parties in SCS, including the 'exercise (of) self-restraint in the conduct of activities that would complicate or escalate disputes', none have adhered to its provisions thus far due to its non-binding nature. Discussions on a binding code have stalled due to China's preference to resolve such disputes bilaterally instead of multilaterally and recent incidents in SCS did not help the cause. Resumption of long-delayed negotiations between Beijing and ASEAN on a binding code to govern behaviours at sea holds great promise in enhancing the maritime cooperation and conflict resolution mechanisms between regional states.

Thirdly, the emergence of transnational threats has precipitated the need for multilateral approaches in resolving common security challenges that are beyond the powers of individual states. This opens up opportunities for states, especially the US and China, to cooperate in common causes such as maritime security. States can leverage platforms such as the International Maritime Security Conference, held as part of the biennial International Maritime Exhibition (IMDEX) Asia, and ADMM-Plus's Maritime Security Experts' Working Group to establish a common understanding of maritime security challenges and enhance maritime cooperation among members.[28] As an example, an inaugural Maritime Security Field Defence Exercise was held in October 2013 in Australia, which allowed navies to promote information sharing and develop a baseline for communications at sea.[29]

Lastly, WPNS states should work towards addressing the shortcomings of the recently-agreed CUES as mentioned earlier in this paper. While participation in CUES is currently voluntary and non-binding, WPNS states should also consider making CUES compulsory for both naval and maritime constabulary assets, as well as extend its coverage to non-WPNS states in the Indo-Pacific region through the Indian Ocean Naval Symposium. Navies of signatory states should also make it a point to regularly practise the CUES procedures in multilateral and bilateral exercises to instil confidence that such procedures will be adhered to in the event of an actual contingency at sea.[30]

Military Measures

Increased dialogue and expanded naval cooperation between US, Chinese and regional militaries can go a long way towards soothing inter-state tensions. There are three measures to enhance this. Firstly, regional navies should aim to improve military-to-military communications at the operational level to mitigate the risk of a tactical blunder between naval assets at sea escalating into a full-blown conflict. This can be done through establishing communication mechanisms, such as military hotlines to manage maritime incidents or emergencies. This also serves as a direct channel and line of communication for operational commanders to clarify any misunderstandings.[31] A case in point is Japan, who has recently urged China to set up a hotline between the maritime authorities of both countries to prevent unnecessary escalations, given their frequent encounters with military and naval assets in disputed waters and airspace. This came after a Chinese aircraft buzzed a Japanese aircraft that China claimed had breached its ADIZ without permission in May 2014.[32] Similarly, China and Vietnam had established a hotline to inform each other of fishery boats' detainments within 48 hours of an incident.[33]

Secondly, the 1972 US-Soviet INCSEA proved to be an effective instrument for confidence-building and tension mitigation during the Cold War, and the establishment of an INCSEA-like agreement can aid in easing tensions caused by frequent interactions at sea. Although the US and China had signed a Military Maritime Consultative Agreement (MMCA) in 1998, this only acts as a consultation mechanism for regular meetings and possesses no concrete measures to respond to incidents such as the USNS *Impeccable* and EP-3 incidents. Moving forward, both militaries

Two Chinese trawlers stop directly in front of the Military Sealift Command ocean surveillance ship USNS Impeccable, forcing the ship to conduct an emergency 'all stop' in order to avoid collision.

The Senkaku/Diaoyu islands are a group on uninhabited islands. Diaoyu island is marked in blue, on the left of the island chain.

should seriously consider establishing an INCSEA-like agreement or bolstering the MMCA mechanism to include practical measures to manage and prevent incidents between both militaries.[34]

Lastly, regional navies should leverage multilateral and bilateral exercises to enhance cooperation and build mutual trust and understanding. Joint naval exercises can also encourage greater military transparency and help to develop interoperability among navies, such as the PLAN-organised WPNS sea exercise in April 2014. These will enhance navies' abilities to cooperate in areas of common interests such as humanitarian assistance, disaster relief and maritime security. Notably, an encouraging sign is the PLAN's inaugural acceptance to participate in the US-led Rim of the Pacific exercise in July 2014, which will allow participating navies to build confidence and, at the same time, socialise the PLAN to international rules and norms.[35]

While it can be argued that China's agreement to CUES is a positive step forward in reducing the prospects of maritime conflicts in the Indo-Pacific region, this code alone is insufficient to ensure that maritime stability and security will prevail.

Economic Interdependency and Cooperation

There are two economic measures that can help to alleviate inter-state tensions. Firstly, at the macro level, globalisation has resulted in greater economic interdependency between states. States are increasingly reliant on the international maritime trading system, with US$5.3 trillion of trade transacting through the SCS alone annually. In the event of any regional tensions or conflicts, the diversion of commercial shipping to alternative routes and ports can hurt the pockets of regional economies deeply, due to longer transits and lower profit margins. This increased economic interdependency between states can be a powerful enabler to mitigate the risks of states escalating maritime disputes to a full-blown conflict in the region, as well as contribute to the maintenance of regional stability in a virtuous cycle. In this respect, states should continue to foster regional economic cooperation through developing the Regional Comprehensive Economic Partnership (RCEP) and Trans-Pacific Partnership (TPP) mechanisms, which will bring the goal of a Free Trade Area in the region closer to fruition.[37] Once their economies are closely intertwined by trade, the costs of escalating a dispute will be prohibitive and states will be more inclined to consider non-violent means to resolve their differences.

Secondly, the complex maritime disputes in ECS and SCS are unlikely to be resolved anytime soon since they involve sovereignty claims and multiple claimants. Hence, a practical and viable approach forward in defusing tensions is for claimants to set aside their differences and develop mechanisms for multilateral economic cooperation or joint development of resources.[38] This is in line with Deng Xiaoping's advocated principle of "setting aside disputes and pursuing joint development" in relation to the disputed Senkaku/Diaoyu islands in 1979.[39] These can take the form of provisional arrangements of a practical nature, as articulated in UNCLOS's Articles 74 and 83 and most importantly, will be without prejudice to existing sovereignty claims or determination of final maritime boundaries.[40] This is essentially a win-win situation as states can jointly harvest resources in disputed areas to meet their national interests, with no claimants having to back down from their claims. As an example, Japan and the Republic of China have agreed to recognise and protect one another's fishing rights in the Senkaku/Diaoyu islands in April 2013.[41] Another concrete example of joint economic cooperation is China and Vietnam's agreement to establish a working group for the joint exploration of SCS, including the Gulf of Tonkin in October 2013.[42] Hence, the earlier states are willing to cast aside their nationalist sentiments and join hands in creating the necessary political will for joint economic development of resources, the better positioned they will be to defuse maritime tensions and manage potential conflicts in the region.

CONCLUSION

The Indo-Pacific region continues to be characterised by globalisation and economic interdependence between states, with the maritime domain as the global wide commons for regional security and stability. While it can be argued that China's agreement to CUES is a positive step forward in reducing the prospects of maritime conflicts in the Indo-Pacific region, this code alone is insufficient to ensure that maritime stability and security will prevail. Instead, states could adopt a range of policy measures that would help to ease regional maritime tensions and de-escalate the risk of maritime conflicts. Regardless of the forces driving the politics and policies of each country, ultimately, peace and prosperity is the shared common interest of all Indo-Pacific states. With increased economic interdependency between states and their reliance on the international maritime trading system, it remains in all stakeholders' interests to work with each other to adopt a multilateral and cooperative approach in overcoming security challenges and enhancing relations between states. This will mitigate the dangers and risks that states "may sink together if (they) do not swim together."[43] Embracing such an approach will go a long way in helping to defuse inter-state tensions and guarantee the region's continued peace, stability and prosperity into the future.

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Is the SAF's Defence Posture Still Relevant as the Nature of Warfare Continues to Evolve?

by **MAJ Bernard Tay**

Abstract:

In the years following her independence, Singapore has had to build up a credible military force to deter and defend threats to its security, territorial integrity and sovereignty. The author explains the various changes of our deterrence measures and the evolutionary stages of our SAF—from a 1st generation army to the highly sophisticated 3rd generation fighting force we know today. The essay also aims to evaluate how the SAF's defence policies have transformed over the years to better adapt to the recent unconventional threats our nation faces such as cyber-attacks and transnational terrorist attacks. Finally, this essay suggests how the SAF can better collaborate with Homefront agencies, government ministries and international bodies to be more effective in deterring such threats, as well as sustaining a stronger and more credible deterrence force.

Keywords: Deterrence; Unconventional Warfare; National Security; Terrorism; Capability

INTRODUCTION

> *"...since you know as well as we do that right, as the world goes, is only in question between equals in power, while the strong do what they can and the weak suffer what they must."*
>
> *– An extract from the Melian Dialogue*[1]

The past five decades have seen the Singapore Armed Forces (SAF) rapidly transforming itself into one of the region's most technologically advanced and potent fighting forces.[2] As a small nation, the SAF plays an important role to "deter threats to Singapore's security, territorial integrity and sovereignty and, should deterrence fail, to secure a swift and decisive victory."[3] Since independence, the strategy of deterrence has remained a key component in Singapore's defence policy.

In the immediate years following her independence, Singapore had to quickly build up a credible military force to deal with a hostile regional environment. During that period, the 1st Generation SAF provided Singapore's basic defence with a deterrence posture analogous to that of a 'poisonous shrimp'—small, vulnerable, yet deadly to the aggressor when attacked.[4] By the early 1980s, with a better-equipped and more capable 2nd Generation SAF, the deterrence posture morphed into that of a 'porcupine', shredding the previous image of a 'poisonous shrimp' which was "essentially defeatist in nature."[5] The current 3rd Generation (3rd Gen) SAF transformation started in 2004 and aims to "upgrade its capabilities into an advanced networked force."[6] Some military analysts have likened the 3rd Gen SAF's posture to that of a 'dolphin'—agile, intelligent, quick and capable of killing more ferocious sharks with its razor sharp teeth when provoked.[7]

While there have been distinct enhancements to the SAF's warfighting capabilities and its attendant deterrence posture, the nature of warfare has also shifted significantly since the end of the Cold War in the early 1990s.[8] This essay will attempt to discuss the viability of the SAF's deterrence posture against the backdrop of an evolving security landscape. It will argue that while the SAF continues to be effective in deterring the breakout of conventional war against nation-states, its capabilities alone project limited deterrence against emerging unconventional threats involving non-state actors. This essay will explore means to strengthen this deterrence posture through collaborations with other national and international stakeholders. Finally, this essay will highlight key challenges that Singapore will need to address in order to sustain a deterrence posture that is both credible and effective in the years ahead.

ELEMENTS OF AN EFFECTIVE DETERRENCE POSTURE

An effective military deterrence posture is one that is able to dissuade potential adversaries from undertaking actions intended to jeopardise national sovereignty. Deterrence may either come from imposing a high cost of action through the guarantee of retaliation, or by threatening to limit the outcome of the actions, or both. This translates to the two subsets of deterrence theory: (1) deterrence by retaliation/punishment; and (2) deterrence by denial.

For the strategy of deterrence to be effective, the adversary has to believe that the defending nation is able to 'walk the talk'. Credibility is influenced by the defending nation's underlying capabilities to retaliate and/or to deny success and its resolve to act on the deterrent threats. The following section will

Prime Minister Lee Hsien Loong, together with Minister for Defence, Dr Ng Eng Hen (far right), then-Chief of Defence Force LG Ng Chee Meng (far left), and former Chiefs of Defence Force, cutting a cake to commemorate 50 years of SAF defence.

examine how the SAF has projected its deterrence posture from independence until today.

OVERCOMING EXTERNAL THREATS IN THE EARLY YEARS OF INDEPENDENCE

At the time of Singapore's independence, the SAF comprised merely of two infantry battalions with about 1,000 men, two naval patrol crafts, and no Airforce.[9] With the imminent withdrawal of all British troops from Singapore by December 1971, Singapore had to be self-reliant and could no longer rely on her past colonial master for her security.[10] As a 'Little Red Dot' that lacked strategic depth and a hinterland, Singapore had to project a deterrent image to make it undesirable for larger nations to exploit her vulnerability.[11] Being a majority-Chinese nation situated in a Malay Archipelago also added racial elements to an already tensed security landscape.[12]

Deterrence may either come from imposing a high cost of action through the guarantee of retaliation, or by threatening to limit the outcome of the actions, or both.

Not surprisingly, the main external threats in the early years of Singapore's independence came from her neighbours. To express firm opposition to the creation of the Malaysian Federation, Indonesia engaged in a hostile policy of *Konfrontasi*.[13] Singapore became a target of sabotage, bombings and was even considered as a location for a full-fledged military invasion. This offensive policy inevitably left Singapore wary of Indonesia's political intentions years after *Konfrontasi* had ended.[15]

Singapore's relationship with Malaysia did not fare any better. A difference in political ideology and bitter rivalry resulted in the separation of Singapore from Malaysia on 9th August, 1965. Even after separation, the Singapore government was concerned over the urgent priority of building up its own defence capability from scratch.[16] Furthermore, the ongoing war in Vietnam added uncertainty and tension to regional security.

During the tumultuous period following independence, both 1 and 2 Singapore Infantry Regiment (SIR), together with the Singapore Volunteer Corps and the Vigilante Corps, played an instrumental role to "protect strategically important sites."[17] In addition, the military also contributed to the "maintenance of peace and order" by "performing guard duties and conducting section patrols."[18] While the strategy of deterrence was still effective, the inevitable withdrawal of the British forces would severely cripple its credibility.

As result, these driving forces catalysed the build-up of the SAF through the implementation of conscription in 1967 and a steady investment of up to 6% GDP in military defence.[19] By the early 1980s, the SAF had acquired new platforms such as 155mm artillery howitzers, landing crafts, air-lift assets and had trained up a sizeable force to beef up its land, air defence and naval capabilities.[20] With a more capable military force, the SAF was thus able to credibly communicate its true deterrence posture—a military that not only assured a swift and decisive retaliation on its aggressor, but also capable of denying the success of an offensive attack.[21]

STRENGTHENING THE 'PORCUPINE'

After publicly announcing the shredding of the 'poisonous shrimp' image, the SAF continued to recruit and train quality people, develop its warfighting concepts and upgrade its military hardware. In 1991, the Army formed its first Combined Arms Division

President Tony Tan receiving a briefing from Lieutenant Colonel Ooi Tjin Kai, Commanding Officer of RSS Steadfast, on how the Republic of Singapore Navy has developed to build itself up with new equipment, with better capabilities.

that integrated infantry units with mobile Armour platforms, combat support and combat service support elements to "achieve a synergy of mobility, protection and firepower in operations."[22] The Air Force upgraded its fighter aircrafts to the A-4SU Super Skyhawk and strengthened its Ground-Based Air Defence (GBAD) assets while the Navy added missile corvettes and submarines to its fighting arsenal.[23] By the turn of the 21st century, the SAF had transformed into a formidable deterrent force with a strong Army, Air Force and Navy.

Over this period, the SAF was successful in projecting deterrence to avert any armed conflict, while creating greater policy space for Singapore. The presence of a strong SAF also played a key role in enabling Singapore to stand firm on her sovereign rights while resolving disputes with Malaysia arising from the water agreement, the 1990 Points-of-Agreement (POA) and the sovereignty of Pedra Branca.[24]

THE 3RD GENERATION SAF TRANSFORMATION

Singapore has done well on the defence diplomacy front to forge stronger relationships with our regional neighbours through bilateral exercises and multilateral platforms such as the Five Power Defence Arrangement, the Shangri-La Dialogue and the ASEAN Defence Ministers Meeting (ADMM)-Plus. That said, the security challenges in the region continue to be uncertain and precipitous. The ongoing tension over territorial claims of the South China Sea between

China and the four claimant ASEAN countries—namely the Philippines, Malaysia, Brunei and Vietnam—could disrupt regional stability and undermine the regional security architecture.[25] Against this backdrop, Asian countries have increased efforts to modernise their militaries in the last decade, with Southeast Asia seeing a near doubling of conventional arms transfer between 2005 to 2009.[26] As a globalised country with inherent strategic vulnerabilities, it is in Singapore's interest to continue to invest in a strong SAF to serve as the "ultimate guarantor of Singapore's security and sovereignty."[27]

In 2004, the SAF embarked on its 3rd Gen transformation to harness the advancement in technology, optimise the use of resources and better position the SAF in defending against a widened spectrum of threats.[28] It draws from the concepts of the Revolutions in Military Affairs (RMA) which leverages on advanced technology as a 'force-multiplier' on the battlefield. As demonstrated in Exercise Forging Sabre 2011, the 3rd Gen SAF relies on a networked and integrated system-of-systems to acquire timely and accurate information in order to deliver swift and precise fires on the key enemy targets.[29] The 3rd Gen SAF will see greater synergy between the three Services based on the concept of Integrated-Knowledge Command and Control (IKC2) to aid in the decision-making process and the delivery of precise effects.[30]

In 2004, the SAF embarked on its 3rd Gen transformation to harness the advancement in technology, optimise the use of resources and better position the SAF in defending against a widened spectrum of threats

The steady investment in defence capabilities has enabled the SAF to strengthen its deterrence posture with the acquisition of new platforms such as the High Mobility Artillery Rocket System (HIMARS), Leopard 2A4 Main Battle Tank (MBT), Terrex Infantry Carrier Vehicles, Formidable-Class Stealth Frigates with their S-70B Naval Helicopters, F-15SG Fighter Jets, G550 Airborne Early Warning Aircraft, as well the potential acquisition of the F-35 multi-role fighter aircraft and the replacement of the Challenger-class submarine.[31] In addition, the 3rd Gen SAF continues to invest in the training, nurturing and professional development of its soldiers, airmen and sailors, ensuring that they possess both the necessary competencies as well as the will to fight.

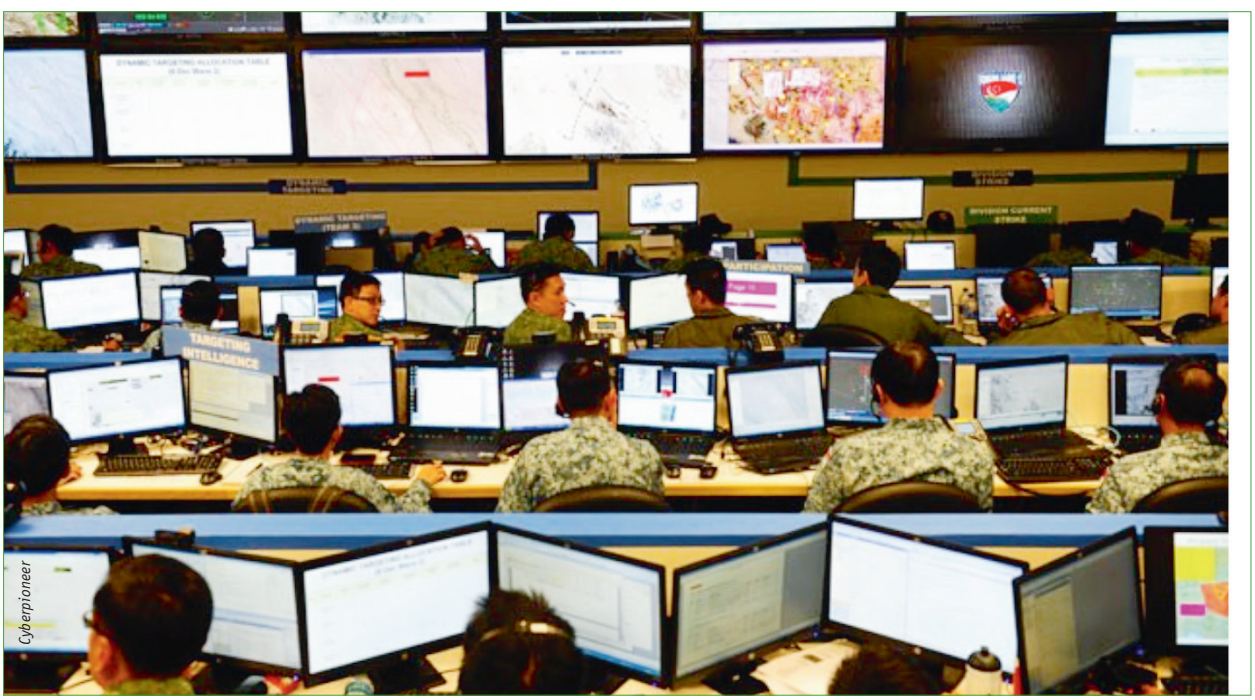
THE EVOLVING NATURE OF WARFARE

While the strategy of deterrence has proven to be effective thus far when dealing with nation-states, it is less so against non-state actors such as terrorists and insurgents. The attack of a Shell oil-refinery by four armed terrorists in 1974 and the hijack of SQ117 by four terrorists from the Pakistan Peoples Party in 1991 lend evidence to this. One prominent theory of the future of warfare is the notion of Fourth-Generation Warfare (4GW). According to William Lind, 4GW is characterised by the return to a decentralised state of warfare waged by violent non-state actors on the nation-state.[32] Their intent is to impose their will on the state government by inflicting maximum damage using low-cost means of aggression such as suicide bombers and guerrilla warfare.[33] Rupert Smith coins this as the “war amongst the people,” which is marked by protracted low-intensity conflict.[34] The killing of innocent hostages by the Islamic State of Iraq and Syria (ISIS) demonstrates this type of warfare waged by terrorist groups using unlawful means of fear and coercion to achieve its political agenda.

PLUGGING INTO A LARGER NATIONAL AND INTERNATIONAL DETERRENCE FRAMEWORK

Albeit a major instrument of national security, the SAF is not and should not be the sole stakeholder responsible for the full-spectrum of unconventional threats which looms over Singapore. The SAF has to remain focused on its primary mission of defending the territorial integrity and sovereignty of Singapore, while working where possible, with other national and international stakeholders to tackle unconventional threats.[35] Thus, the deterrence posture in dealing with unconventional threats should come from a joint effort between multiple local and overseas agencies, and not just from the SAF itself.

Acknowledging the challenge of deterring unconventional threats such as terrorism, piracy and cyber attacks with a largely conventional force, the SAF was reorganised, as part of the 3rd Gen transformation, to be flexible and highly responsive across a full-spectrum of operations. Integrated Task Forces such as the Island Defence Task Force (IDTF), Special Operations Task Force (SOTF), Joint Task Force (JTF) and Maritime Security Task Force (MSTF) were formed to answer to peacetime security threats.[36] The SAF has also recently formed a Cyber Defence Ops Hub to deal with emerging cyber threats.[37] Each of the Task Forces brings together relevant entities from existing SAF-wide resources and works closely with partners from other ministries and Homefront agencies, including the Singapore Police Force and the Singapore Civil Defence Force. The IDTF, for example, works closely with the Homefront agencies when it conducts peacetime security operations such as the protection of key installations, while the MSTF works closely with the Police Coast Guard.[38]



Cyberpioneer

The 3rd Gen SAF - more technologically equipped to deal with emerging cyber threats.

Stakeholders	Type of Deterrence
Military	Deter by Retaliation: Applying necessary force based on Rules of Engagement (ROE) on aggressors. Deter by Denial: IDTF protection of key installations; Cyber defence Hub to deny cyber-attacks; Conduct of coastal patrols by MSTF; JTF to react to Humanitarian Assistance and Disaster Relief (HADR) contingencies; Chemical, Biological, Radiological and Explosive (CBRE) units to respond to bio-chemical threats and contain the spread.
Law Enforcement	Deter by Retaliation: Bringing perpetrators to justice; Imposing travel restriction on family members. Deter by Denial: Internal Security Act to enforce preventive detention and prevent subversion.
Civil Defence	Deter by Denial: Quick response to limit damage.
Racial and Religious Groups	Deter by Denial: Promoting racial and religious harmony; Rehabilitation of radicalised Muslims.
Media	Deter by Denial: Limiting media coverage of terrorist attacks to prevent spread of terrorists ideology and demands; Block out websites which promote radicalisation; Spread messages of moderate religion and social harmony.
Financial Regulatory	Deter by Retaliation: Impose huge penalty on organisations, nations that finance insurgents, terrorist activities, spread of on Weapons of Mass Destruction (WMD). Deter by Denial: Economic resilience to recover quickly; To deny financing of Terrorism and WMD proliferation.
Public	Deter by Denial: Physical and psychological resilience to recover from shock quickly; Being vigilant and alert to possible threats; Knowing how to react during contingencies to mitigate ill-effects.

Table 1: National Deterrence Framework against Non-Conventional Threats.

At the international front, the SAF's overseas contribution to the International Security Assistance Force in Afghanistan, as well as in a Multi-National Counter-Piracy Task Force, Combined Task Force (CTF) 151, contributed to the international efforts in deterring transnational terrorism and piracy. After the Indian Ocean tsunami struck neighbouring countries on Boxing Day 2004, the SAF's professionalism and quick response to provide aid to disaster-hit cities in Indonesia added credibility to its deterrence posture.[39]

Taking a leaf from the Total Defence framework of Military, Social, Civil, Economic and Psychological Defence, *Table 1* proposes a national deterrence

framework which highlights how each key stakeholder can contribute to strengthen Singapore's deterrent posture against such threats. Although the strategy of deterrence may be limited, the ability to deter some threats makes it still a relevant strategy for Singapore. Ultimately when deterrence fails, the SAF, together with the Homefront Agencies, have to work closely to deal with the threats swiftly and decisively.

SUSTAINING A STRONG AND CREDIBLE DETERRENT FORCE

Thus far, this essay has addressed the SAF's deterrence posture from a capability perspective. As a conscript force, the people's will to fight and defend the nation also play a large factor in the SAF's credibility. A recent survey conducted by the Institute of Policy Studies found strong support for National Service (NS), with 98.5% of respondents agreeing that "NS is necessary for the defence of Singapore."[40] The Committee to Strengthen NS (CSNS) was set up in early 2013 to explore means to maintain strong public support for NS. Going forward, it is important for MINDEF/SAF to strengthen the defence narrative so that future generations will continue to believe in the purpose of NS. With a greater competition for the national budget to fund other commitments such as social welfare benefits, education and public transport, the SAF has to continue to be prudent in its defence spending, and may need to justify harder for a consistent share of the budget. Hence, there will be a need for policymakers to increase the level of engagement with the public on defence policies to achieve greater buy-in.[41]

The media plays an important role in shaping perception as well as winning hearts and minds. In the information age, the SAF has to be innovative and adaptable in communicating, using a broad range of media platforms to reach out to its audience. Having strong strategic communication capabilities will aid in the projection of SAF's deterrence posture into the mindshare of potential aggressors.

Acknowledging the challenge of deterring unconventional threats such as terrorism, piracy and cyber attacks with a largely conventional force, the SAF was reorganised, as part of the 3rd Gen transformation, to be flexible and highly responsive across a full-spectrum of operations.

CONCLUSION

The SAF has served its mission in ensuring Singapore's peace and security through her rapid development from a Third to First World Country. This is a result of astute defence policies put in place by the first generation of political leaders, notably the late Dr Goh Keng Swee. The evolving threats in the 21st century will require the SAF be adaptive and to work in collaboration with other Homefront Agencies, government ministries and international bodies in order to be more effective in deterring and dealing with such threats. Most importantly, to ensure Singapore's survival, the current and future generations of Singaporeans must continue to place a premium on defence, and be willing to pay the price for peace and security.

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3D Printing – Revolutionising Military Operations

by **ME5 Calvin Seah Ser Thong & ME4 Choo Wei Wen**

Abstract:

3D Printing has proven to be an innovative and revolutionary piece of technology with potentially significant applications for the military. In this essay, the author explores its technology, applicability and challenges before proposing a framework for our army to undertake 3D Printing. Firstly, he gives a brief overview of the technology behind the printing process and the various printing methods. Next, he highlights the abundance of possible military applications of 3D Printing, including the production of military equipment both during peacetime and on the battlefield for immediate use. Other uses include protective armour for soldiers, prosthetics, surveillance tools and even food. However, given the nascent stage of technology, there are challenges that need to be addressed such as Intellectual Property rights, liability, occupational health and safety, cost and quality standards. The author concludes by suggesting a framework to mitigate these challenges, which includes creating a task force to study the feasibility of this technology and disseminate 3D Printing-related knowledge. There is no doubt that the prudent use of 3D Printing technology will yield innumerable benefits for our army.

Keywords: 3D Printing; Invention; Technology; Military Applications; Quality

INTRODUCTION

> *"3D Printing is already shaking our age-old notions of what can and can't be made."*
>
> *– Hod Lipson, Associate Professor of Mechanical Engineering, Cornell University*[1]

It has often been said that necessity is the mother of invention. This leads us to see inventors as problem-solvers, doing what they do to overcome problems and challenges. However, this is not always so in the modern world. Instead, invention seems to be the mother of necessity, where new products can create needs that we have never felt before. The long lines that accompany each iPhone release are evidence of this. Throughout history, we have seen many daily necessities that originated from military inventions, including Global Positioning System (GPS) technology, microwave ovens and the Internet. However, we now see an innovative and game-changing technology from the manufacturing industry that could become a necessity for the military—Additive Manufacturing (AM), or commonly known as 3D Printing.

3D Printing, which manufactures a 3D solid object from a digital model, is a form of Rapid Prototyping (RP) technology that enables speed-to-market. 3D Printing is currently used to produce a plethora of commercial and industrial products and can potentially have significant military applications. Lieutenant Commander Michael Lienza from the United States (US) Navy was enticed by the

technology after personally seeing how one broken part could hold an aircraft back from a combat mission and affect military readiness. He said, "For the Navy, the technology promises to shift inventory from the physical world to the digital one...instead of actual parts, a ship might carry 3D Printers and bags of various powdered ingredients, and simply download the design files needed to print items as necessary."[2] With its potential to be a game changer for the military, this article thus explores its technology, applicability and challenges before proposing a framework for the military to undertake 3D Printing.

3D PRINTING TECHNOLOGY REVOLUTION

> *"We have 3D printing, a machine which can print spare parts, print models, print toys, print pistols, print body parts, organs; print things which can make a difference to our lives."*
>
> *– Prime Minister Lee Hsien Loong*[3]

The increased competition of manufactured products in the world has made it vital for new products to reach the market as early as possible.[4] 3D Printing, which manufactures a 3D solid object from a digital model, is one such method to enable speed-to-market. Although it was initially used for the purpose of RP during the early 1990s, advances in technology have allowed further applications in the area of industrial manufacturing, aerospace engineering as well as biomedical replacement. Industry interest in 3D Printing has grown with increased support from the private sector, while the Singapore government has also announced the allocation of S$500 million over the next five years to boost capabilities in advanced manufacturing, with 3D Printing a key area.[5]

Printing Process

3D Printing is the process of building a three-dimensional solid object from a digital model. The printing process is akin to that of printing a typical document, in that it requires an input file (3D model) and a printer. The 3D models of the object to be printed would firstly need to be created either through Computer-Aided Design (CAD) programmes or 3D scanners. The 3D Printer subsequently builds the component by adding successive layers of material, based on the layers defined by the file. However, due to the quality of printed components and the support structures that may be built as part of the manufacturing process, there is a need to perform additional post-processing on the 'printed' product to ensure usability. There may also be a further need to subject the produced part to testing and qualification to ascertain that the part produced conforms to its

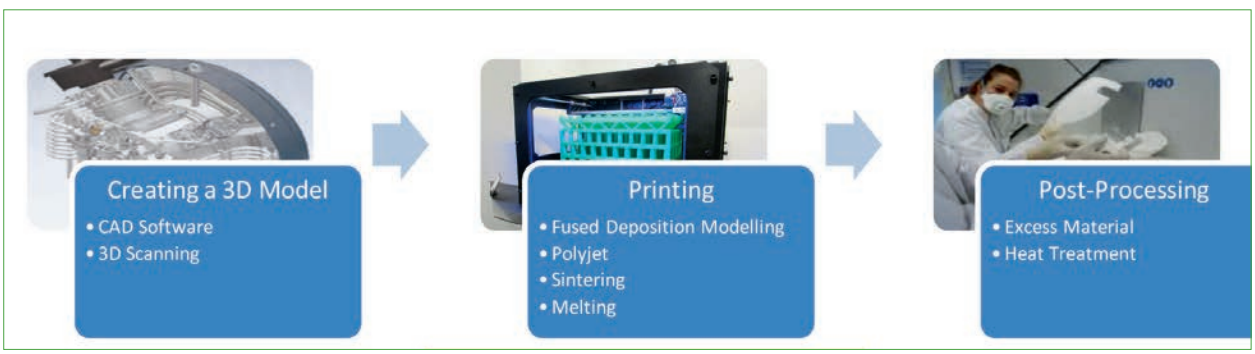


Figure 1: Additive Manufacturing Process.

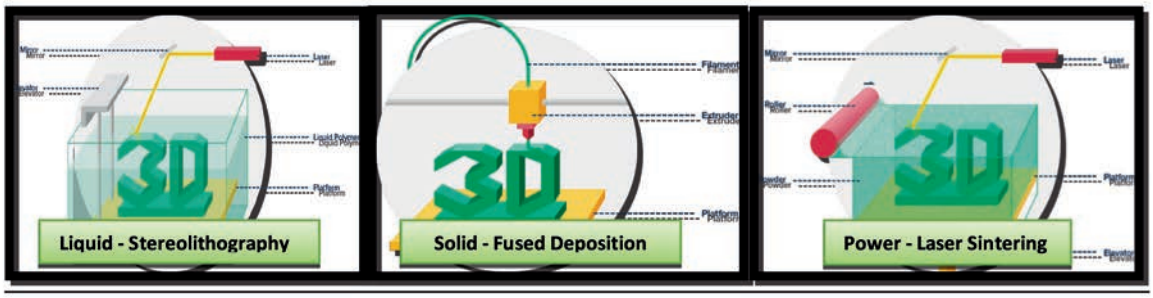


Figure 2: 3D Printing Methods.

requirements. It typically consists of three processes which are illustrated in *Figure 1*.

Printing Methods

There are several categories of 3D Printing methods currently available in the market, with each differing in the way it produces the layers of materials to be added and types of materials that are suitable for them. They are typically classified by the material that the prototype is built with and are broadly categorised into: (1) liquid based; (2) solid based; and (3) powder based. Examples of 3D Printing systems under each category are shown in *Figure 2*.

POTENTIAL MILITARY APPLICATIONS

Imagine an operation in which you are a lone soldier tasked to capture a terrorist in a building. You first despatch your 3D-printed drone to scan

Figure 3: Potential 3D Printing Military Applications.[6]

the building. Upon confirmation of the terrorist's location, you enter the building and engage your target. As you move towards him, he shoots at you. However, your 3D-printed armour is able to protect you and fully absorbs the shock. You are then able to counter him with your 3D-printed gun and take him down. As you head back, your vehicle breaks down. However, you are able to turn it around by printing the malfunctioning part, using your portable 3D Printer. While the depicted scenario is hypothetical, 3D Printing may potentially fulfil the following military applications shown in *Figure 3* and elaborated in the following paragraphs.

Maintain – Peacetime

3D Printing can allow Just-in-Time and on-demand production of prototypes for trial purposes, before full-scale production proceeds. Due to the low tolerances of the 3D Printing process, complex components that used to require difficult machining and assembling can be manufactured at once. This can potentially allow Military System Managers to rapidly develop and implement innovative solutions to platforms, boosting their performance and safety. It has been reported that parts manufactured through 3D Printing, including protective covers and support struts, have been used on the Royal Air Force's (RAF) Tornado fighter jets.[7] Furthermore, militaries with smaller fleets may face difficulties in prototyping potential modifications or parts to existing platforms, since minimum order quantities may not be met to be economical. 3D Printing can

Figure 4: A Complex Gear System Produced Using 3D Printing without supporting assemblies.

Display of one of the REF's Expeditionary Labs.[8]

Annette LaFleur, team leader for NSRDEC's Design, Pattern and Prototype Team.[9]

therefore help mitigate such potential difficulties through Just-in-Time and on-demand production. In addition, 3D Printing can overcome the issue of obsolescence which poses a challenge to the long-term maintenance of the military systems through on-demand manufacturing of obsolete components.

With the forward deployment of 3D Printers in the Area of Operations, it is possible for maintenance personnel to manufacture components for immediate use. This can thus help reduce the load that is carried by maintenance forces, which in turn reduces the logistics tail.

Maintain – Operations

Lastly, the on-demand nature of 3D Printing can be applied to the battlefield as well. With the forward deployment of 3D Printers in the Area of Operations, it is possible for maintenance personnel to manufacture components for immediate use. This can thus help reduce the load that is carried by maintenance forces, which in turn reduces the logistics tail. This concept has, in fact, been implemented by the US Army's Rapid Equipping Force (REF), through the deployment of their Expeditionary Lab-Mobile (ELM) in Afghanistan. The ELM is a 20-foot container equipped with a 3D Printer and other workshop equipment and has allowed the US Army to produce items from simple canteens to replacement parts.[10]

Protect

Researchers at the US Army Natick Soldier Research, Development and Engineering Centre (NSRDEC) are currently incorporating 3D Printing into the uniform design process. It is envisaged that 3D

Printing could play a major role in the production and advancement of the clothing and armour worn by soldiers, both on and off the battlefield. For one, there would be less stitching and seams required in garments. Clothing could be catered to the exact size of a particular solider, while design programmes could determine how to print each piece with the least number of seams and stitches as possible. Such an accomplishment could be a boost to the comfort of a soldier, especially during long, tough missions. Other potential applications could also include the printing of ballistic materials for armour, in precise shapes, making it less expensive and more efficient for a soldier's protection.

Reconstruct

In the past, soldiers who were wounded on the field would have to continue with a disfigured arm or face. Now with 3D scanning technology, the soldier can do a 3D scan before he or she is deployed. This would ensure all physical features are saved on file and should the soldier come back wounded, his 3D data can be extracted and used to build a prosthesis that is exactly how he used to look instead of sculpting.[11] Researchers have also been able to 3D print custom facemasks of a patient's face out of a material called Polycaprolactone (PCL). They are then able to generate skin over the custom mask by depositing a collagen-based wound matrix, allowing for the skin to grow in a pre-determined shape and thus producing a near-perfect fit for the patient.[12]

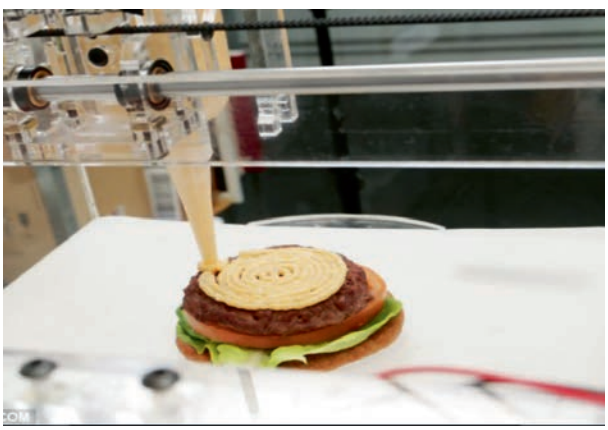
Sustain

Army researchers are currently investigating ways to incorporate 3D Printing technology into producing food for soldiers. Currently, most 3D Printing applications for food consists of a paste that comes out of a printer and is formed into pre-determined shapes. Food technologists at the US Army NSRDEC hope to create nutrient-rich foods that can be consumed in a warfighter's specific environment on or near the battlefield. Nutritional requirements could be sent to a 3D food printer so meals can be printed with the proper amount of vitamins and minerals, thus meeting the individual dietary needs of the warfighter.[14]

3D printed body parts created by researchers at Wake Forest Institute for Regenerative Medicine.[13]

Sense

The University of Maryland's Maryland Robotics Centre was contracted by the US Army to design the Robo-Raven as a surveillance tool that would blend



3D Printed Food.[15]

in with its surroundings. Robo-Raven is made of 3D-printed, lightweight and thermal-resistant plastic in addition to carbon fibre, foam and Mylar foil. Its 3D-printed components imbue the bionic bird with an agility that has been so similar to real birds that real birds of prey have actually attacked it.[16]

Robo-Raven in flight.[17]

POTENTIAL CHALLENGES

While 3D Printing promises many possibilities, there are challenges which need to be addressed as follows:

Legal Issues

Since 3D Printing can give the Army the means to manufacture components and parts that were designed, and possibly patented, by past suppliers, there is a valid concern over the issue of Intellectual Property (IP) rights infringement. In fact, at this current juncture, other governments such as the US and the European Union are still grappling with such an issue. This may necessitate the need for militaries to procure the rights to manufacturing data such as CAD files for their acquisitions. It has been assessed that 3D Printing may lead to widespread copyright theft, if printing any 3D item is as easy as downloading a song or movie illegally. Should a CAD file of a firearm be easily downloadable, it might potentially be a huge safety issue. Currently in the US, a handgun has been printed by a 3D Printer, assembled and successfully test-fired by a firearms manufacturer.[18]

Liability

Should a part that was produced by 3D Printing fail and result in damage or injury, it is unclear who will be held responsible: the 3D Printing machine Original Equipment Manufacturer (OEM), originator of Stereolithography (STL) file or personnel operating the machine. To mitigate the uncertainty in this area, it may be conservative to identify a group of personnel who are allowed to undertake the task of 3D Printing, as well as to establish a set of standards to govern the 3D Printing process. This also brings up the issue of the standards that should be used to test and qualify printed components. An effective initial proposal is to adopt the original testing requirements that were used during the manufacture process by the component OEM. Using the same qualification procedures, it will provide the assurance that the quality of the product from 3D Printing will be at least the same as that of the original.

Since 3D Printing can give the Army the means to manufacture components and parts that were designed, and possibly patented, by past suppliers, there is a valid concern over the issue of Intellectual Property rights infringement.

Occupational Health & Safety

Since 3D Printers make use of high voltage power supplies, hot surfaces and fine powdered materials, they can increase the risk of hazards to the health and safety of personnel operating them. A study in 2013 by the Illinois Institute of Technology reported that a small desktop 3D Printer had emission rates similar to that of a cigarette burning indoors. Therefore, the necessary safety infrastructure must

be established and safety codes adhered to, so as to minimise these risks. Studies have also shown that 3D Printing could create health problems if done in areas without proper ventilation due to the emissions from printing. The study results suggest that the printers which are using Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA) polymers as plastic feedstock were 'high emitters' of ultrafine particles or UFPs, which can be deposited in the lungs and absorbed into the bloodstream.[19]

True Cost of Manufacture

Just as there is a Total Cost of Ownership (TCO) associated to every system, there is also a need to consider the Total Cost of Manufacture (TCM) for 3D Printing, which may be much higher than expected. This can be attributed to the materials required to make support structures during the 3D Printing process, as well as the loss of material that could not be reused. This is particularly applicable for extrusion methods such as Fused Deposition Modelling (FDM), which require the use of support material. Therefore, when budgeting for 3D Printing, the TCM should be taken into consideration.[20]

Quality Standards

Quality certification is needed to ensure that the parts printed are up to standard. This is due to a lack of world certification standards currently on 3D Printing. There are many issues that 3D Printing is now facing with the quality of parts, such as geometrical deviations, porosity and surface roughness.

FRAMEWORK FOR 3D PRINTING

Capability Development Roadmap

While the technology for 3D Printing continues to mature, it is necessary to establish a build-up plan so as to effectively leverage on the available 3D Printing technologies. It would be necessary to firstly establish the capability for 3D Printing and subsequently to sustain the capability. A proposed capability development roadmap is shown as follows:

Enabling Phase: Building Up the Foundation

The first phase of the capability build-up will focus on establishing a baseline of knowledge and competency related to 3D Printing, as well as validating the outputs of 3D Printing:

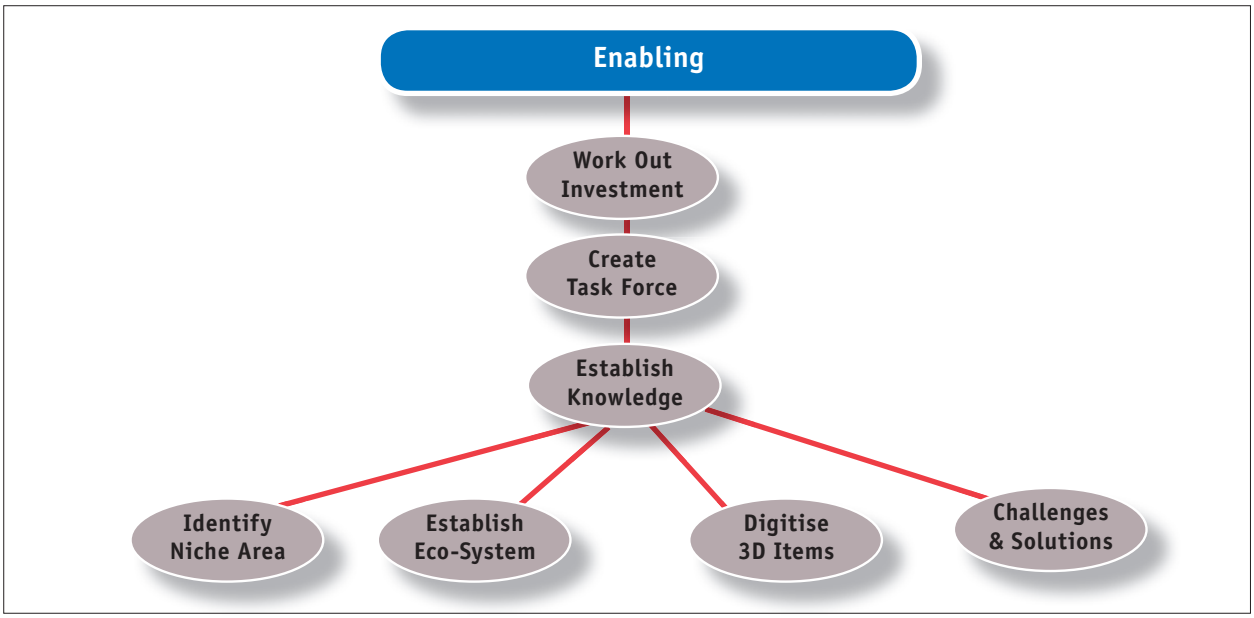


Figure 5: Enabling 3D Printing Capability.

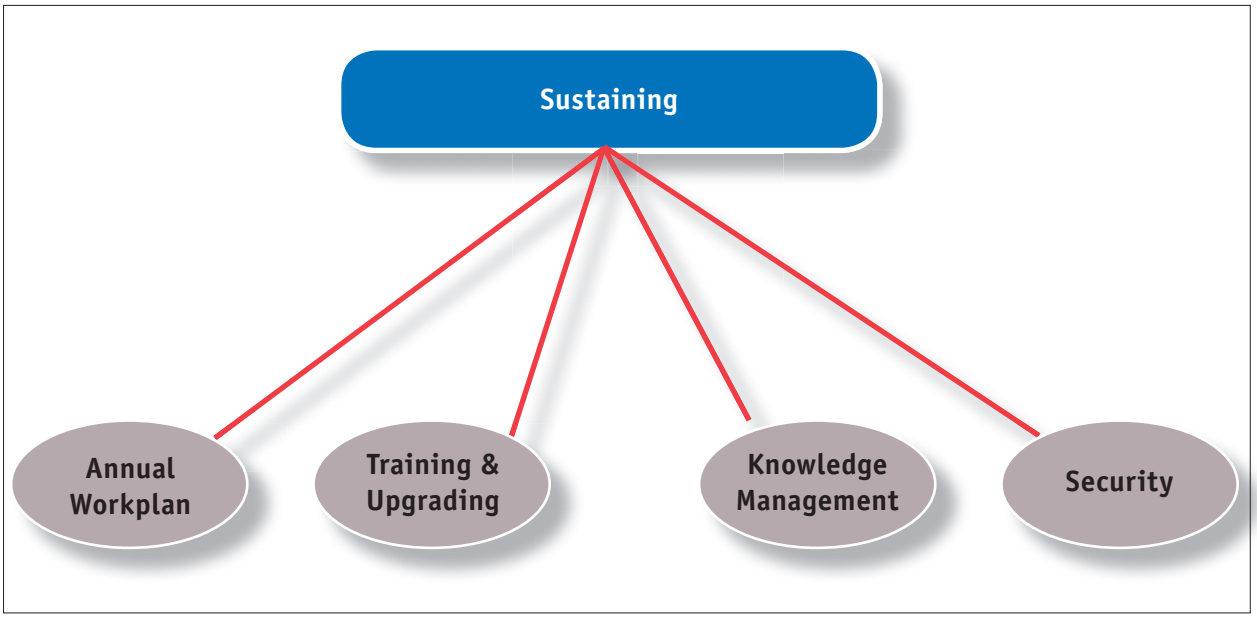


Figure 6: Sustaining 3D Printing Capability.

Work Out Return of Investment

There is firstly a need to consider and compute the return of investment that 3D Printing can bring versus current manufacturing methods. At the same time, cost computations may need to be done on the whole supply chain, as having just the technology is not enough. Considerations on the whole supply chain would need to be studied.

Create a 3D Printing Task Force

This team will identify the uses of 3D Printing and study its feasibility. As 3D Printing is progressing rapidly, the team would also need to be the eyes and ears for the military in keeping up to date with the current technology. It will also coordinate on the various levers of policies in relation to 3D Printing for the organisation.

Establish 3D Printing Knowledge & Competency

This will include sending personnel to courses and seminars (local or overseas) on 3D Printing or RP. The objectives would be to familiarise themselves with 3D Printing technologies and develop an understanding of possible 3D Printing strategies that can be adopted by the military. The knowledge gained can then be disseminated through pilot 3D Printing workshops.

Identify 3D Niche Areas

As it is not possible for everything to be 3D printed, there is a need to consider the niche areas that 3D Printing can be applicable, as well as to ensure non-infringements on printed items. The classification of items to be printed would therefore be necessary.

Establish 3D Printing Eco-system

As it may not be viable for the military to own and print their own items, it would be a necessity to establish a 3D Printing eco-system consisting of partners and suppliers. This would also be required for the long term sustenance of the technology.

Digitise 3D-Printable Items

To enable 3D Printing, the digital files of the part to be printed are essential. There would therefore be a need to digitise all the parts that have been classified to be 3D Printable. This would ensure that when the need arises, the items can be printed.

In theory, it should be possible to send a few 3D Printers to a warzone where they would use local materials to replicate themselves and then, based on digital images stored in their computers, produce an endless stream of military hardware.

Study Challenges and Derive Potential Solutions

As mentioned earlier, while 3D Printing holds many promises, there are many challenges which need to be overcome before it can reach full potential. There is therefore a need to study all the various challenges and derive potential solutions to overcome them.

Sustaining Phase: Ensuring Sustenance

With the setup of the 3D Printing task force and the initial groundwork on the feasibility of 3D Printing, the focus will shift towards operationalising the applications of 3D Printing for the military. Applications for both peacetime and operational uses should be considered. While it may be unlikely that the military print its own parts, a 3D Printer could still be purchased for experimentation and work on possible innovations.

CONCLUSION

This article has explored 3D Printing technology and its potential applications for the military. It has also highlighted its challenges and proposed a framework for the military to undertake 3D Printing. However, this is only the beginning. Future generations of 3D Printers could be made large enough to make parts for weapons systems, military vehicles or even aircraft. In theory, it should be possible to send a few 3D Printers to a warzone where they would use local materials to replicate themselves and then, based on digital images stored in their computers, produce an endless stream of military hardware. The applications of 3D Printing are therefore limited only to the imagination of the inventor. Indeed, with its many potential applications to the military, it is an invention that could be the 'mother of necessity' for the military.

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The Lanchester Square Law: Its Implications for Force Structure and Force Preparation of Singapore's Operationally-Ready Soldiers

by **LTA(NS) Philip Chan**

Abstract:

In this essay, the author explains the Lanchester Square Law Theory and links it to the concept of Relative Combat Power (RCP). RCP is defined as the effectiveness of a force in killing an enemy. The author shows the implications of the Lanchester Square Law for tactics in combat, by exploring test-cases of battles between a seven-man and ten-man section. Next, he explains how Admiral Lord Nelson's tactics at the Battle of Trafalgar were in fact an application of the Lanchester Square Law. He feels that the importance of numbers has implications for the force structure of our army and the advantage of an opponent's numbers needs to be compensated by a significant increase in the quality of our own forces. In his opinion, the commanders should maintain a high baseline of quality in peacetime, as Singapore depends heavily on both the quantity and quality of our Operationally-Ready servicemen. Only then can the SAF harness the advantages of quantity and quality, enhanced by detailed and coordinated planning, to secure a swift and decisive victory over any aggressor.

Keywords: Quantity and Quality; Outcome of Battle; Survival; Tactics; Force Preparation

INTRODUCTION

> *"He will win who knows when to fight and when not to fight;*
>
> *he will win who knows how to handle both superior and inferior forces..."*
>
> *- Sun Zi*[1]

In September 2015, an eight-man Special Air Service (SAS) team was ambushed in Syria by at least 30 militants, while smuggling a secret agent into Syria. The SAS team was "out-gunned and out-numbered" but regained the initiative "by using courage, aggression and firepower."[2] In fact, one SAS soldier outgunned six militants. Eventually, the SAS team eliminated the ambush and killed eight militants.[3]

Does the quality of soldiers matter more than their quantity? In this essay, the author explains the Lanchester Square Law and links it to the concept of Relative Combat Power (RCP). RCP is defined as the effectiveness of a force in killing an enemy. The author shows the implications of the Lanchester Square Law for tactics in combat, by exploring test-cases of battles between a seven-man and ten-man section. Next, he explains how Nelson's tactics at the Battle of Trafalgar were in fact an application of the Lanchester Square Law. Finally, the author concludes by highlighting: (1) the importance of numbers and implications for our Army's force structure; and (2) the importance of quality and implications for force preparation of our operationally-ready forces.

THE LANCHESTER SQUARE LAW AND RCP

According to the author, the Lanchester Square Law allows us to compare the RCP of two fighting forces and anticipate the outcome of battle. In this section, the author highlights three points: (1) RCP of a force is not the number of units; but (2) the RCP is proportional to the square of the number of units and proportional to the quality of units; and (3) if we know the qualities and numbers of two forces at the start of a battle, we can tell the outcome.[4]

Consider two forces, Red and Blue, engaged in combat. Each soldier knows the locations of their targets and shifts fire to a new target when the previous target is destroyed. Let functions R(t) and B(t) represent the numbers of Red and Blue forces fighting at any time t, where t>0. The original numbers of Red and Blue forces are R(0) and B(0). Let the quality of each unit of forces be defined by the number of enemy units it destroys per unit time, where each unit of Red forces destroy r blue units per unit time, and each unit of Blue forces destroy b red units per unit time.

Then, the rate of Red forces being destroyed is:

$$dR/dt=-bB \quad [1]$$

Similarly, the rate of Blue forces being destroyed is:

$$dB/dt=-rR \quad [2]$$

Dividing the two equations to eliminate t , we obtain:

$$dB/dR=rR/bB \quad [3]$$

Cross-multiplying both sides gives:

$$bBdB=rRdR \quad [4]$$

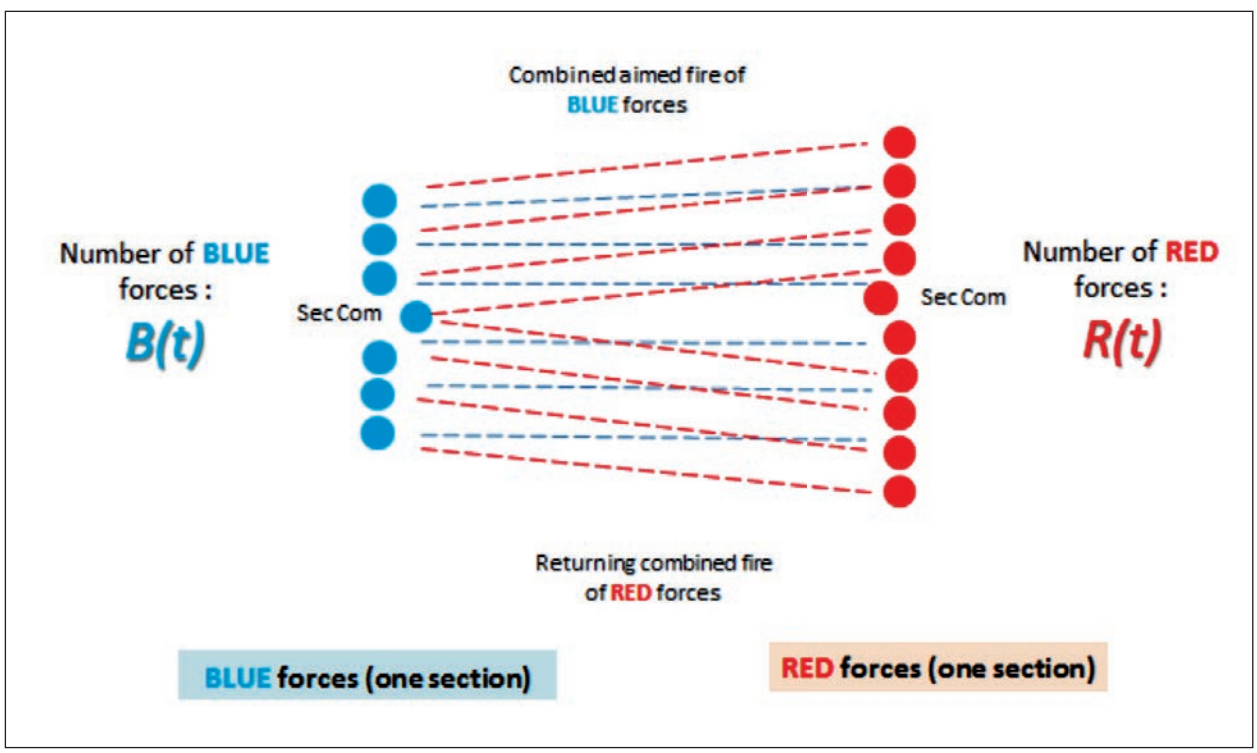

Figure 1: Illustration of Battle between R(t) Numbers of Red Forces and B(t) Numbers of Blue Forces.

Integrating both sides over all time t, from t=0 to arbitrary time t:

$$b\int BdB=r\int RdR \quad [5]$$

$$bB^2(t)-rR^2(t)=bB^2(0)-rR^2(0) \quad [6]$$

Note that the difference between $bB^2(t)$ and $rR^2(t)$ is the same for all time, because t can represent any time as long as $t\geq 0$. So, we can claim that the difference $bB^2(t)-rR^2(t)$ equals constant K:

$$bB^2(t)-rR^2(t)=bB^2(0)-rR^2(0)=K \quad [7]$$

Equation (Eq.) [7] is the Lanchester Square Law: the difference $bB^2(t)-rR^2(t)$ is a constant all the time. K remains the same throughout the battle, whether at the start (at t=0), or at any later time t at the end. This means that if Blue forces begin with $bB^2(0)>rR^2(0)$, they will definitely win at the end because $bB^2(t)$ will always be greater than $rR^2(t)$.[5]

The K value determines which force wins. If K=0, then:

$$bB^2(t)=rR^2(t) \quad [8]$$

This is the case that both forces are equally-matched, and fight till both are eliminated.

If K>0, then:

$$bB^2(t)>rR^2(t) \quad [9]$$

This is the case that Blue forces win, when $bB^2(0)>rR^2(0)$ at the start of the battle. If $K<0$, then:

$$rR^2(t) > bB^2(t) \quad [10]$$

This is the case that Red forces win, when $rR^2(0) > bB^2(0)$ at the start of the battle.

The Lanchester Square Law thus gives the following results: $rR^2(t)$ and $bB^2(t)$ represent the RCP of each force that measures how effectively a force attrites another. The RCP of a force is not the number of units. Instead, the RCP is proportional to the *square* of the number of the units, and proportional to the quality of the units. Moreover, from Eq. [7] we know that the difference between the RCP of two forces is equal to a constant K. Therefore, if we know the numbers and qualities of two forces at the start of a battle, we can anticipate which side will win.

APPLICATION TO SIMPLE CASES OF COMBAT

In this section, the author applies the results of the discussion above to model two simple cases of combat. Do note that the numbers used are hypothetical and are used for illustration only.

Test Case 1

Consider a test-case where both Blue and Red soldiers are of the same quality, with a seven-man Blue infantry section against a ten-man Red section. Let both forces have quality q. We want to determine which side wins and with how many surviving troops.

At the start, the RCP bB^2 of the seven-man Blue infantry section is:

$$bB(0)^2=q(7)^2=49q \quad [11]$$

The *RCP* rR^2 of the ten-man Red infantry section is:

$$rR(0)^2=q(10)^2=100q \quad [12]$$

Since $rR^2(t) > bB^2(t)$, then by Eq. [10], the Red section will eventually win due to its superior RCP because it has more numbers. At the end, the Red section will completely destroy all Blue forces (i.e. B(t)=0). We can calculate the number of surviving

Red forces, by substituting the values into Eq. [7]:

$$bB^2(t)-rR^2(t)=bB^2(0)-rR^2(0) \quad [13]$$

$$0-qR^2(t)=49q-100q \quad [14]$$

$$R(t)=\sqrt{51}=7.14\approx 7 \quad [15]$$

This example implies that in a battle between a seven-man section and a ten-man section of the same quality, the seven-man section will be wiped out (survival rate of 0%) while the ten-man section will lose only three soldiers (with seven soldiers surviving - a survival rate of 70%).

Therefore, the side with superior numbers will lose *fewer* soldiers and has a *higher* survival rate. In a battle between two forces of equal quality, the difference in numbers exerts a significant effect on the outcome.

Test Case 2

Consider a case where both Blue and Red forces are seven-man sections, with Blue forces of quality q and Red forces of lower quality 2/3 q. We want to determine which side wins, and with how many surviving troops.

At the start, the *RCP* bB^2 of the seven-man Blue infantry section is:

$$bB(0)^2=q(7)^2=49q \quad [16]$$

The RCP rR^2 of the seven-man Red infantry section is:

$$rR(0)^2=2/3\ q(7)^2=32.7q \quad [17]$$

Since $bB^2(t)=49q$ is greater than $rR^2(t)=32.7q$, then by Eq. [9], we know that the Blue section will win,

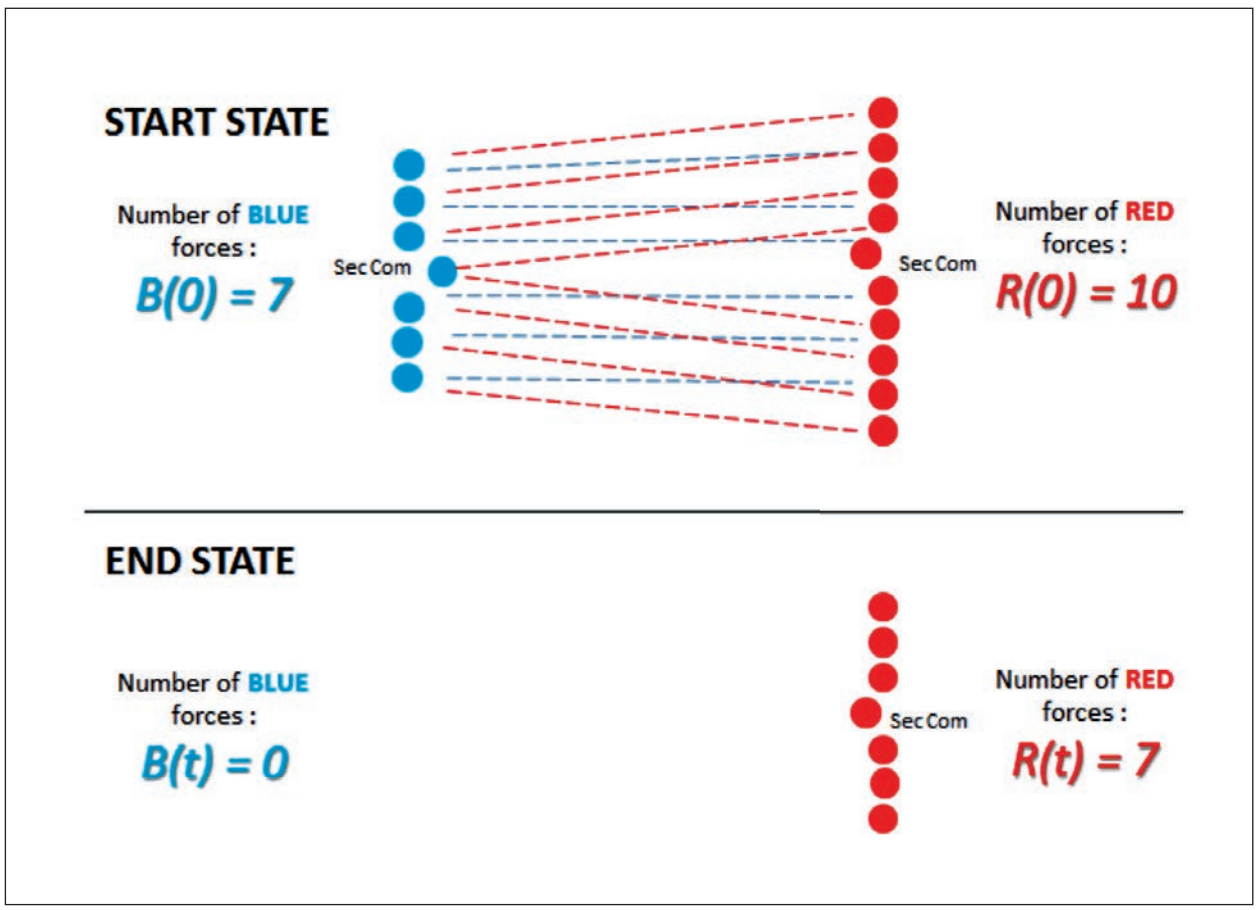

Figure 2: Comparison of Number of Blue to Red Soldiers and Start State and End State.

due to its greater quality. At the end, the Blue section will completely destroy all Red forces. We can calculate the number of surviving Blue forces:

$$bB^2(t)-rR^2(t)=bB^2(0)-rR^2(0) \quad [18]$$

$$qB^2(t)-0=49q-32.7q \quad [19]$$

$$B(t)=\sqrt{16.3}=4.04\approx 4 \quad [20]$$

This implies that in a battle between a seven-man Blue section of quality q and a seven-man Red section of lower quality 2/3 q, the seven-man Red section will be wiped out while the seven-man section will lose three soldiers (with four soldiers surviving—a survival rate of 58%).

As compared to the difference in numbers, the difference in quality between two equally-sized forces has a lesser effect on the outcome of battle. In this example, the survival rate of the side with superior quality is 58%, compared to 70% in the earlier example.

TACTICS FOR BATTLES

These following cases suggest some tactics for commanders:

1. If Blue forces are outnumbered but are of greater quality, they can defeat a Red enemy force of lower quality. Commanders should use Tactics of Concentration—to divide the Red forces into smaller groups, so that Blue forces have greater quantity and quality (and so greater RCP) in each battle against the smaller groups of Red forces. The Blue forces can take on these smaller groups of Red forces one by one, eventually wiping them out.

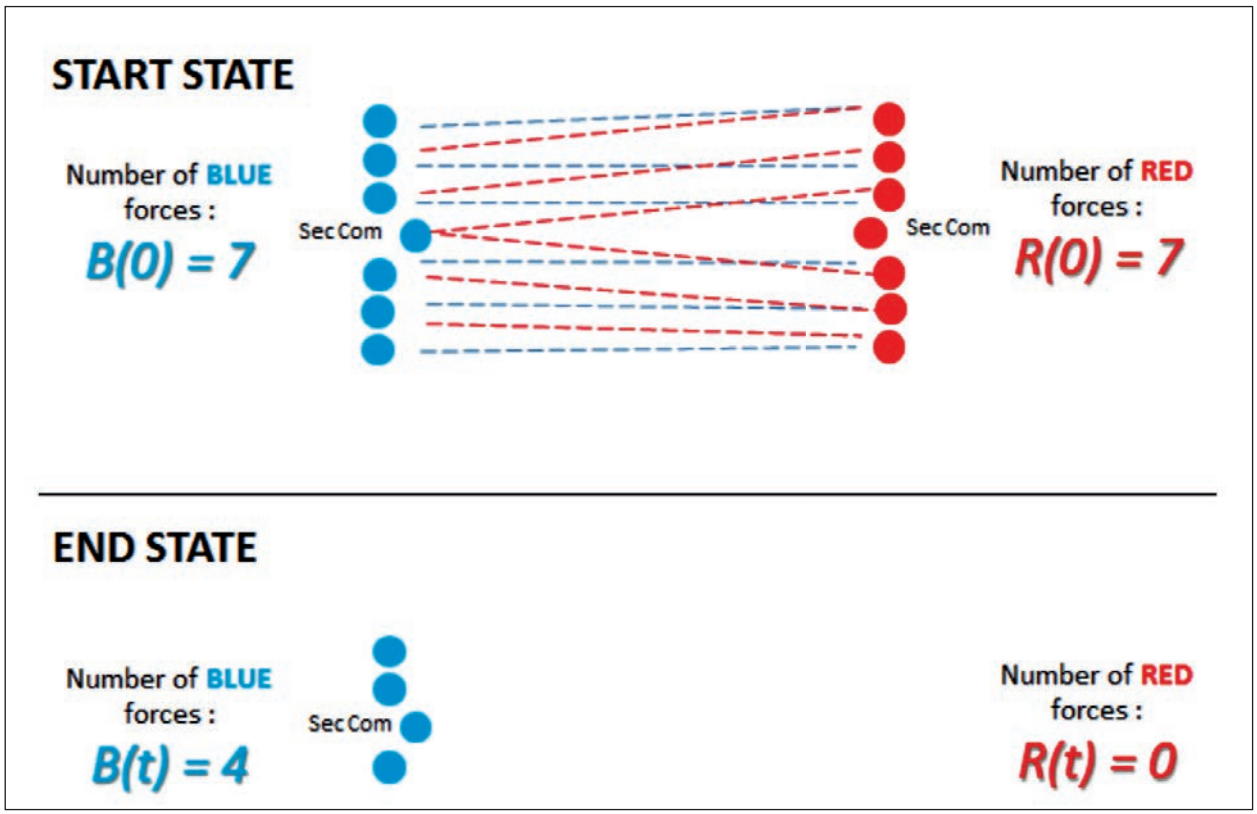

Figure 3: Comparison of Number of Blue to Red Soldiers and Start State and End State.

2. If Blue forces have greater numbers but of lower quality, they can defeat a smaller enemy force of greater quality. Commanders should use Tactics of Numbers—to prevent the Red forces from dividing Blue forces (i.e. prevent Red forces from using Tactics of Concentration against them).

3. If Blue and Red forces are evenly matched in numbers and quality, commanders should not fight the enemy head-on. Instead, commanders should use Tactics of Division—to use terrain, time and location to set up a battle favourable to them. This could involve the deliberate setting of decoys, traps and surprise manoeuvres.

For convenience, these tactics can be summarised in *Table 1* below.

Case-Study: Battle of Trafalgar (1805)

The results of the Lanchester Square Law can be applied to the Battle of Trafalgar (1805), between the British fleet led by Admiral Lord Nelson and the Franco-Spanish fleet led by Admiral Pierre-Charles Villeneuve. At the start, the British fleet had twenty-seven ships and a total of 2,148 naval guns. The Franco-Spanish fleet was greater in numbers, with thirty-three ships and 2,568 naval guns.

We can calculate the RCP of the British to Franco-Spanish fleet at the start of the battle. For simplicity, we assume that the quality of British and Franco-Spanish forces depends on: (1) the number of naval guns; and (2) the quality of crew. Assume further that the Franco-Spanish crew were two-thirds as effective as the British crew. This is reflected in *Table 2* on the next page.

On paper, the Franco-Spanish fleet had superior RCP and would secure a decisive victory. The Franco-Spanish advantage in numbers would compensate for the lower quality. However, history tells us that the outcome of the battle was a decisive British victory with no ships lost (a survival rate of 100%). The defeated Franco-Spanish fleet lost 22 ships (a survival rate of 18.5%).

How did Nelson achieve victory? In the nineteenth century, a common tactic of naval combat involved a naval fleet forming up in a single line, approaching the enemy fleet, also in a single line, then using all the guns on one side to engage the enemy. Both fleets would be in parallel lines. Instead, Nelson bucked the trend. According to Nelson's plan, the British fleet would cut the Franco-Spanish line into three parts. The British ships would approach in two columns of 13 ships and 14 ships, in a direction perpendicular,

Numbers of Blue forces		Quality of Blue Forces		
		Lower quality than Red	**Same quality as Red**	**Greater quality than Red**
	Smaller numbers than Red	Avoid battle	Avoid battle, apply Tactics of Division if unable to avoid battle	Apply Tactics of Concentration
	Same numbers as Red	Avoid battle, apply Tactics of Division if unable to avoid battle	Apply Tactics of Division	Apply Tactics of Concentration
	Greater numbers than Red	Apply Tactics of Numbers	Apply Tactics of Numbers	Engage immediately

Table 1: Classification of Tactics in Different Contexts of Combat.[6]

	British	Franco-Spanish
Quantity (of ships) B(0) and R(0) (in units)	27	33
Quality (of guns and crew) b and r (in units of thousands)	2.148×3=6.4	2.568×2=5.136
RCP bB^2 (0) and rR^2 (0) (in units)	**4,698**	**5,593**

Table 2: Comparison of RCP between British and Franco-Spanish Fleets.

instead of parallel to the Franco-Spanish fleet.[8] This would cut the numerically superior Franco-Spanish line into three parts: a front group, middle group, with the command element, and rear group.

In his commander's guidance, Nelson gave two pointers: (1) to cut-off the enemy's rear; and (2) to concentrate superior force on the rear elements.[9] In the first phase, the two columns of British ships

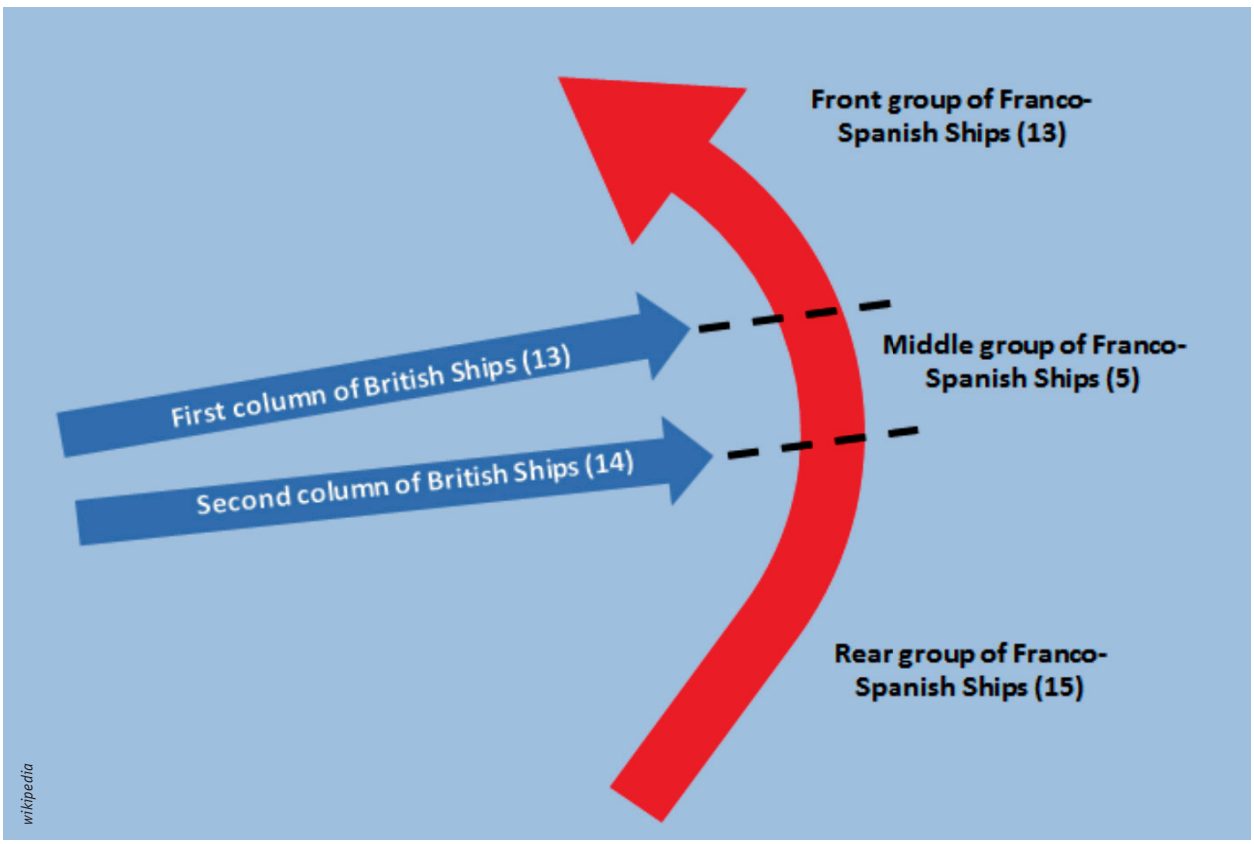

Figure 4: Distribution of British and Franco-Spanish Ships at the start of the Battle of Trafalgar.

	British	Franco-Spanish
Quantity (of ships) B_1 (0)+B_2 (0) and R_1 (0)+R_2 (0)+R_3 (0) (in units)	Column 1: 13 Column 2: 14	Group 1: 13 Group 2: 5 Group 3: 15
Quality (of guns and crews) *b* and *r* (in units of thousands)	2.148×3=6.4	2.568×2=5.136
RCP bB_1^2 (0) + B_2^2 (0) and rR_1^2 (0) + rR_2^2 (0)+ rR_3^2 (0) (in units)	$(6.4)(13)^2+(6.4)(14)^2$ = **2336**	$(5.136)(13)^2+(5.136)(5)^2$ $+(5.136)(15)^2$ = **1864**

Table 3: Comparison of RCP in First Phase of Battle between British and Franco-Spanish Fleets.

would cut the Franco-Spanish line, to isolate the front group of the Franco-Spanish line from the middle group. Separated from the rest, the front group would be forced to re-group, turn back and support the rear elements. The middle group, with the command element, would be isolated from the front and rear groups it commanded, and so command and control would break down. This would allow the second phase to occur—the British could concentrate forces on the rear group of the Franco-Spanish fleet. Nelson's plan would also bring about ship-to-ship combat between the British and Franco-Spanish ships, where the seamanship, faster gunnery and higher morale of each British crew could defeat a Franco-Spanish ship.

We can see the effects of Nelson's tactics on the RCPs of the British and the Franco-Spanish fleets. In the first phase, Nelson's two columns of ships cut up the enemy's line to reduce the total RCP of the enemy ships. *Table 3* above shows that the British tactic to divide up the Franco-Spanish fleet would give the British superior RCP.

In the second phase, one of Nelson's columns with 14 ships, could take on the enemy's rear group of 15 ships. Thus, with almost equal numbers of British and Franco-Spanish ships, this would lead to a ship-to-ship fight. Each British ship could then capitalise on its advantage of superior quality over another Franco-Spanish ship. This is illustrated in *Table 4* on the next page.

Nelson's fleet avoided head-on confrontation with the numerically superior Franco-Spanish fleet. In essence, Nelson's plan to cut-up the enemy into smaller groups illustrates *Tactics of Concentration*. To re-cap, the tactics state that a commander should "divide the Red forces into smaller groups, so that Blue forces will have greater quantity and quality in each battle against the smaller groups of Red forces.

	British	Franco-Spanish
Quantity (of ships) B(0) and R(0) (in units)	14	15
Quality (of guns and crews) *b* and *r* (in units)	3	2
Relative Combat Power bB_1^2 (0) and rR^2 (0) (in units)	**588**	**450**

Table 4: Comparison of RCP in Second Phase of Battle between British 14-ship Column and Franco-Spanish Rear Forces.

The Blue forces can take on these smaller groups of Red forces one by one, eventually wiping them out."[10]

In sum, the results of Lanchester's Square Law can be directly applied to modelling combat engagements. In fact, Lanchester asserted that Lord Nelson, "if not actually acquainted with the Square Law, must have some equivalent basis on which to figure out his tactical values."[11]

Nelson's fleet avoided head-on confrontation with the numerically superior Franco-Spanish fleet. In essence, Nelson's plan to cut-up the enemy into smaller groups illustrates Tactics of Concentration.

Comments on Validity of the Lanchester Square Law

Several authors have attempted to verify the validity of the Lanchester's Square Law. They compared actual results from historical battles such as the Ardennes, Kursk and Iwo Jima and idealised battles at the US Army National Training Centre, against the values predicted by the Square Law. The results indicate that the RCP in actual situations is not bB^2, but closer to bB^{Υ}, where Υ ranged from 1 to 1.5.[12] Many factors in actual combat could explain the deviation, including the lack of fire control and discipline, the arrival of reinforcements, the effect of combined arms and support elements and the effect of the 'ace firer/pilot' (a minority of gunners is attributed the majority of the kills).[13] We should not expect that the Lanchester Square Law will be fully accurate. Rather, it is a useful heuristic to allow commanders to think about the RCP of two forces for quick decision-making in battle.

IMPLICATIONS FOR FORCE STRUCTURE AND FORCE PREPARATION IN SINGAPORE'S CONTEXT

At this juncture, the author highlights that we should take stock of the above discussion, to derive implications for force preparation, structure and training.

Importance of Numbers: Implications for the Singapore Army's Force Structure

The results of the Lanchester Square Law show that numbers give rise to a quality of their own.[14] From the first learning point in *Table 5* below, we see that RCP of a force is bB^2. If the enemy has thrice our numbers, our forces will need to be three-squared (nine) times better in quality to achieve RCP parity.

As Singapore's birth rate falls, we need to adjust our force structures to meet operational outcomes. By 2047, the number of 18-year old males available for conscription will shrink to 29,906, a 20.5% reduction from its peak of 37,619 in 2012.[15] This will affect our force structure build-up during National Service and our Operationally-Ready National Service forces.

The Army has already reduced the size of the section to seven men by compensating with increased firepower. The 20% reduction in the cohort size may prompt us to make further cuts in manpower-intensive areas (e.g. infantry sections and platoons). However, we cannot indefinitely shrink our force structures at the tactical level. In *Table 6* on the next page, I consider the effects of shrinking a seven-man section to six men on the RCP, compared to the RCP of an aggressor ten-man section.

The RCP of the seven-man section is half that of the ten-man section. To achieve parity with the ten-man section, the seven-man section would need to double its quality (through superior training or increased weapon effectiveness). The six-man section would have to triple its quality to achieve parity with the aggressor section. Each soldier of the six-man section will need to be physically fitter, more accurate in aim and exhibit greater teamwork, in order to take out the ten-man section.

Moreover, the effect of casualties on the RCP of a section is significant. One and two seriously-wounded casualties will have major impact. For each casualty, at least one additional soldier will have to provide immediate buddy-level aid. This reduces the RCP of the section dramatically, illustrated in *Table 7* on the next page.

The figures are clear. With one casualty and one additional soldier providing buddy aid, the individual quality of soldiers of the seven-man section has to be four times better than the quality of enemy soldiers. With two casualties and one soldier providing buddy aid, the quality of soldiers has to be seven times higher. In the extreme case of the six-man section

S/N	Theme	Learning Point
1	Lanchester Square Law	The RCP of a force is proportional to the square of the numbers of units and proportional to the quality of units.
2		If we know the qualities and numbers of two forces at the start of a battle, we will know the outcome of the battle.
3	Implications of the Lanchester Square Law	The side with superior numbers will lose fewer soldiers and has a higher survival rate, than the side with fewer numbers (which will be completely eliminated at the end of the battle).
4		The difference in numbers between two forces of equal quality has a larger effect on the outcome of battle, than the difference in quality between two forces of equal numbers.

Table 5: Summary of Learning Points.

	Original Blue Seven-Man Section	Revised Blue Six-Man Section	Red Ten-Man Section
Quantity B(0) and R(0) (in units)	7	6	10
Quality *q* (in units)	*q*	*q*	*q*
RCP $bB^2(0)$ and $rR^2(0)$ (in units)	*49q*	*36q*	*100q*

Table 6: Comparison of RCP between Six-Man, Seven-Man, and Ten-Man Sections.

	Original Blue Seven-Man Section		Revised Blue Six-Man Section		Red Ten-Man Section
Quantity *B*(0) and *R*(0) (in units)	7		6		10
Effective Quantity (with Blue forces incurring	One Casualty (with one buddy)	Two Casualties (with one buddy)	One Casualty (with one buddy)	Two Casualties (with one buddy)	
Casualties) (in units)	5	4	4	3	10
Quality q (in units)	q		q		q
RCP $bB^2(0)$ and $rR^2(0)$ (in units)	25q	16q	16q	9q	100q

Table 7: Comparison of RCP between Six-Man, Seven-Man, and Ten-Man Sections, in the Event of Blue Forces Incurring One or Two Casualties.

with two casualties and one providing buddy aid, the individual quality of soldiers of the six-man section has to be at least ten times higher. This is an unreasonably lofty expectation that even Special Forces soldiers cannot be naturally assumed to attain. Therefore, the results of the Lanchester Square Law show that numbers give rise to a quality of their own. Going forward, the Army will need to exercise caution when changing the force structure of units at the tactical level.

Since the quality of a force directly depends on superior firepower, the SAF must continue to invest in defence capabilities that provide accurate, precise and high volumes of fire.

This leads us to the second point—the reduction in the size of cohort available for enlistment impacts our Operationally-Ready National Service forces. The size of cohort affects both the size of Singapore's resident labour force as well as the manning levels of operationally-ready units, because both draw from the same pool of people. Operationally-Ready units face issues such as competing demands from employers and the increased movement of Singaporeans abroad for study or work during In-Camp Training (ICT) periods. A wise organisation should ensure little change to the personnel of combat groups, so that comrades in peacetime manoeuvres shall be comrades in war.[16] Therefore, NS commanders must ensure a high level of manning and minimal disruption to unit structures by managing the inflow and outflow of NSmen in each ICT cycle.

Importance of Quality: Implications for Force Preparation of Singapore's Operationally-Ready Forces

The second learning point from *Table 5* is: if we know the qualities and numbers of two forces at the start of a battle, we will know the outcome of the battle. So, force preparation is critical, because: (1) how we task-organise and concentrate forces at the start of the battle directly impacts the outcome; (2) and peacetime training establishes a baseline for wartime performance.

The overall quality of forces depends on many factors. In ground combat fire-fights, this may be reduced to superior firepower (weapon effectiveness, accuracy of fire and rate of fire), teamwork and the effective use of terrain. Since the quality of a force directly depends on superior firepower, the SAF must continue to invest in defence capabilities that provide accurate, precise and high volumes of fire. For instance, the vehicle-mounted remote controlled weapon systems (e.g. systems on board the Terrex Infantry Carrier Vehicle) would give our forces superior accuracy of fire and rate of fire, and thus higher quality. Commanders would also have to keep a high level of force preparation before battle and during re-organisation, so that these weapon systems continue to deliver under battle conditions.

The quality of a force also depends on how effectively soldiers are able to use their firepower and their combined teamwork. For NS commanders, we must focus on factors within our control to ensure a high baseline quality during peacetime. This justifies the conduct of the Big Three during In-Camp Training—physical fitness, marksmanship training, combat fitness—in addition to section and platoon-level drills, first-aid and chemical defence training. While quality, compared to quantity may have less contribution to RCP, every commander has a duty to maximise force preparation to strengthen the quality of soldiers. This gives them the best chances of victory in combat.

CONCLUSION

Sun Zi observed that "he will win who knows how to handle both superior and inferior forces."[17] In this paper, the author has shown that the Lanchester Square Law gives us a simple framework to compare the relative combat power (RCP) of two forces that commanders at all levels—including junior commanders—can use. From Eq. [7], the Law shows that the RCP of a force is proportional to the square of the number of the units and proportional to the quality of the units, and the difference between two relative combat powers bB^2 (t) and rR^2 (t) is constant throughout the battle.

The onus is on commanders to maintain a high baseline of quality in peacetime, as Singapore depends heavily on both the quantity and quality of our Operationally-Ready servicemen.

The results of the Lanchester Square Law suggest tactics of Concentration, Numbers and Division that commanders should adopt when dealing with superior and inferior forces. The importance of numbers has implications for the force structure of our army and the advantage of an opponent's numbers needs to be compensated by a significant increase in the quality of our own forces. The onus is on commanders to maintain a high baseline of quality in peacetime, as Singapore depends heavily on both the quantity and quality of our Operationally-Ready servicemen. Only then can we harness the advantages of quantity and quality, enhanced by detailed and coordinated planning, to secure a swift and decisive victory over any aggressor.

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Cognitive Biases: The Root of Irrationality in Military Decision-Making

by **CPT Chen Jing Kai**

Abstract:

In this essay, the author explores the different types of military decision-making by the operational staff and how it might affect the rationality of their assessment of the current situation The author then provides examples for each different type of bias, which include overconfidence bias, confirmation bias, disconfirmation bias, availability bias, sunk cost fallacy and anchoring bias and proposes ways to mitigate such biases, so that the Singapore Armed Forces (SAF) can be more accurate in their assessment and thus make better decisions. The author concludes by highlighting that in combination with contextual factors, cognitive biases have been shown to result in starkly inaccurate assessments and therefore poor military decisions at the strategic and operational levels. He highlights that the SAF needs to be cognisant of these biases and to implement strategies to counteract them.

Keywords: Cognitive Bias; Decision-Making; Logical; Probability; Magnitude

INTRODUCTION

Operational staff who had previously participated in a Singapore Armed Forces (SAF) high level exercise would understand that they need to provide multiple options for decision makers. These options include different courses of military action straddling the strategic and operational levels. Almost always, there are no perfect solutions; operational staff would therefore need to rationally review and compare the associated costs and benefits across the various options. Indeed, the SAF's doctrine articulates the need to logically outline the strategic pay-offs and political costs for military options to facilitate decision-making. Similarly, established foreign militaries provide decision-making matrices, which detail the pros and cons of each option, to support the logical comparison across options.[1]

In assessing the costs and benefits of the options, the operational staff must carefully consider two important factors: (1) the magnitude of each cost and benefit; and (2) the probability of each cost and benefit materialising. It is interesting to note that individuals can differ remarkably in their estimation of such probability. Consider Napoleon's discussion with his top lieutenants over whether they should invade Russia in 1812. The latter warned against the invasion, citing significant risks to blood and treasure, as well as a high risk of failure. Napoleon, however, saw his invasion plan as swift, decisive and hence low-risk.[2]

As a matter of fact, there can only be one real probability value for each cost and benefit materialising. Granted, we often cannot calculate that exact value, owing to the lack of perfect information in the real world. However, if we assume that the operational staff are rational, that they share the same

information and that they put it on the same decision matrix as dictated by military doctrine, we should expect the estimated probabilities to be similar. This is often not the case because we are not always rational in reality. Indeed, research in behavioural economics has demonstrated that we are susceptible to cognitive biases, which are patterns of deviation in judgment that lead to irrationality.[3]

Borrowing from such research, this essay seeks to explore the common types of cognitive biases that might skew the operational staff's rational assessment of probabilities and hence affect decision-making at the strategic and operational levels. These biases include the overconfidence bias, confirmation bias, disconfirmation bias, availability bias, sunk cost fallacy and anchoring bias. This essay then proposes ways to mitigate such biases.

OVERCONFIDENCE BIAS

> *"Guard against arrogance, avoid underestimating the enemy, and be well prepared."*
>
> *- Mao Tse-Tung*[4]

Before the final battle of the Chinese Civil War in 1949, Mao Tse-Tung ordered his coastal army commanders to guard against the overconfidence bias.[5] This is a cognitive bias that result in the inaccurate calibration of probabilities, by leading individuals to falsely believe that they are more accurate in their judgements than they actually are. Psychological experiments have provided ample evidence for this concept. In a spelling task, only about 80% of the subjects' responses were correct when they were '100% certain' of their answers.[6]

The overconfidence bias is more pronounced when the individual of concern is an expert in the discipline.[7] In the discipline of Warfighting, there are few experts who could have rivalled Napoleon Bonaparte, hailed by Carl von Clausewitz as 'The God of War'. Prior to the invasion of Russia, Napoleon had already planned and orchestrated an impressive 35 victorious campaigns and only losing three. As mentioned previously, Napoleon's subjects had painted a bleak prospect for the Russian campaign. Nevertheless, Napoleon's stellar track record gave him boundless confidence that 'through sheer force of will', he would be able to surmount the glaring challenges he faced and subjugate Russia. The over-confidence bias could never have been more obvious, with the palpable risks of the campaign nullified in Napoleon's mind. Alas, the terrible miscalculation of risks and consequent attempt to invade Russia saw Napoleon's 500,000-strong Grand Army reduced to less than 20,000 men and thwarted his ambition to dominate Europe.[8]

CONFIRMATION AND DISCONFIRMATION BIAS

> *"It is a capital mistake to theorize before one has data. Insensibly, one begins to twist facts to suit theories, instead of theories to suit facts."*
>
> *– Sherlock Holmes*[9]

In the novel, *A Scandal in Bohemia*, by Sir Arthur Conan Doyle, Sherlock Holmes had found a mysterious letter in the post. Curious about what the letter actually meant, Watson, Holmes' trusty companion, had asked for his theory on this matter. As we can see from his response, Holmes, ever the fine detective, was careful to avoid confirmation bias, which is the tendency to favour information that confirms one's hypothesis, regardless of its credibility.

The overconfidence bias is more pronounced when the individual of concern is an expert in the discipline

This bias causes individuals to selectively search for evidence that supports their preconceived

Napoleon's withdrawal from Russia, a painting by Adolph Northen.

hypotheses and believe that such evidence has a disproportionately higher probability of being true, than in reality. Confirmation bias was brought to its extreme during the series of events leading up to the Japanese attack on Pearl Harbour in 1941. Prior to being fundamentally surprised, the top brass in Washington clung to the deep-seated belief that Tokyo was incapable of mounting a raid on Pearl Harbour.[10] Among a series of assessments fraught with confirmation bias, the top brass readily accepted the ridiculous proposition that the Japanese would not be able deliver their bombs accurately for a successful raid, given their severe myopia—attributable to the shape of their pilots' eyes.[11]

The flipside of confirmation bias is disconfirmation bias. This is the tendency for individuals to set more stringent standards of evidence for hypotheses other than their own.

Disconfirmation bias contributed significantly to the fundamental surprise of the Israeli Defence Force by the Egyptian offensive, during the Yom Kippur War in 1973. Then Director of Military Intelligence, Major General Eli Zeira was instrumental in developing 'The Concept', which captured assumptions about Egypt's military strategy. 'The Concept' articulated that Egypt would only attack Israel if it had the air power generation capability to strike Israel's rear operating air bases, so as to reduce their air superiority. As Egypt would only have achieved this capability at least two years later, Zeira assessed that Egypt would not attack Israel.[12] Little did Zeira know that Anwar Sadat, the Egyptian leader, sought to retake the Suez Canal, rather than defeat the Israeli forces. Therefore, the Egyptian forces' lack of air power was not a showstopper. On 6th October, 1973, 100,000 Egyptian troops commenced

their attack on the 450 Israeli soldiers along the Suez Canal. The Israelis were fundamentally surprised.

Along the way, Zeira committed several disconfirmation biases. Before the attack, the Israelis had clear evidence of the Egyptians' attack plans and military deployment. However, Zeira discounted the possibility that Egyptian forces were massing for an attack and chose to situate the evidence in the context of the Egyptian forces conducting a training exercise, buying into the Egyptian forces' deception plan. This was despite the lack of evidence for actual training being conducted on the ground. Even when Jordan's King Hussein undertook a clandestine flight to Tel Aviv to warn the Israeli Prime Minister about Syria and Egypt's intention to attack Israel, Zeria was unmoved. Disturbingly, even when an operative at the highest levels of Egypt's government sent a warning to Israel just hours before the offensive, Zeria chose not to believe the report. It was proposed that his insistence on a flawed theory and playing down of contrary indicators contributed to his failed assessment of Egypt's intention to attack.[13]

AVAILABILITY BIAS

> *"(Post 9/11), 1,500 Americans died on the road in the attempt to avoid the fate of the passengers who were killed in the four fatal flights... This estimate is six times higher than the (latter)."*
>
> *- Gerd Gigerenzer*[14]

Gigerenzer, a German Psychologist, observed that post 9/11, people flew substantially less (reduction of 12-20%) and drove substantially more (mileage clocked by cars on interstate highways increased between 2.2-5.7%). Gigerenzer offered that many might have chosen driving over flying, probably in fear of experiencing another terrorist attack. At the same time, the number of fatal road accidents every month, for the 12 months following September 2001, turned out to be significantly higher than the baseline for the preceding five years. Overall, it was estimated that six times more Americans were killed on the road as they tried to avoid the risk of flying, than the fatalities from the four fatal flights in the 9/11 incident.[15] While the cause of increased land-based travel is probably multi-factorial in reality, this serves as a conceptual example of the availability bias.

The availability bias refers to the tendency for individuals to assess probabilities based on how readily they can retrieve memories of the issue at hand.

The availability bias refers to the tendency for individuals to assess probabilities based on how readily they can retrieve memories of the issue at hand. Retrievability of memories, in turn, will depend on how familiar, vivid or emotionally salient these memories are. Several studies, including the one conducted by Gerd Gigerenzer, have suggested that shortly after a terrorist attack, people tend to believe that another attack is much more probable than it is, in reality. In fact, people tend to be more worried about the risk of another terrorist attack than other statistically more significant risks that they face in everyday life.[16]

Granted, this bias could be beneficial, because "if one thing actually occurs more frequently and therefore is more probable than another, we probably will be able to recall more instances of it."[17] However, it is also important to remind ourselves that the emotional salience and vividness of a memory also determine how readily it is retrieved. This has implications for the interpretation of rules of engagement during military operations. As the decision maker deliberates on whether to target an individual undertaking, an act that might or might

An American F-15E Strike Eagle similar to one used in the attack on NATO fuel trucks that had been hijacked by Taliban forces in 2009.

not be threatening, the ease of retrievability of recent or salient examples of others undertaking similar acts will invoke the availability bias.

On September 2009, a German commander ordered an airstrike on North Atlantic Treaty Organisation (NATO) fuel trucks that had been hijacked by Taliban forces. The hijacked trucks had gotten stuck while crossing the Kunduz River and dozens of civilians had gathered around the trucks to siphon free fuel from the tankers. As a result, the airstrike killed up to 142 people, including over 100 Afghan civilians.[18] Despite the fact that the trucks had not moved for more than four hours, the German commander had perceived an 'imminent threat' (this being a necessary condition for ordering an airstrike), noting that "my feeling was that if we let them get away with these tankers, they will prepare them to attack police stations or even the (Provincial Reconstruction Team)."[19] The German commander seemed to have based his decision on recent and salient events. Indeed, Taliban fighters had detonated a tanker truck in Kandahar not too long ago.[20] Moreover, there had been several other hijackings of the German Provincial Reconstruction Team's tanker trucks by the Taliban in Kunduz.[21] In addition, just one month before the airstrike, intelligence had suggested that the Taliban was planning to overrun the German camp, using explosive-laden trucks.[22] All these easily retrievable events could have contributed to the availability bias that affected the German commander's assessment of the seriousness and imminence of the threat that the hijacked trucks had posed, ultimately leading to his ill-fated decision.[23]

SUNK COST FALLACY

> *"Throw good money after bad"*
>
> *– English Proverb*[24]

This proverb describes people's hopeless commitment of more resources to reinforce a poor decision that has already proven to be costly. In the end, instead of recouping their previous loss, they incur further loss. Such an irrational escalation of commitment of resources can often be explained by the 'sunk cost fallacy'. This is the tendency for people to justify additional investment based on how much resources they have already invested in a decision—and that they will not be able to get back (therefore termed 'sunk costs'). This occurs despite evidence demonstrating that the potential costs for maintaining the decision will be significantly greater than the potential benefits.

Sunk cost fallacy, in the case of military strategy, could result in the unnecessary protraction of wars due to fears that war-termination would result in wastage of the human lives, money and time previously expended. This could, in turn, result in a greater loss of human lives, money and time. Some have argued that the United States' (US) long-drawn involvement in the Vietnam War was an excellent example of this bias. Back then, a key argument made by supporters for the war was that the US' withdrawal from Vietnam would disparage the many who had already sacrificed their lives, letting them 'die in vain'. Therefore, the country 'owed' it to these war heroes to 'stay the course'. This line of reasoning, reinforced by mounting numbers of individuals who 'sacrificed their lives', arguably contributed to the protraction of the Vietnam War and, therefore, produced another 250,000 more casualties.[25]

Steve Jobs, Apple's then CEO, introducing the iPad.

ANCHORING BIAS

> *"What should we price it at? If you listen to the pundits, we're going to price it at under $1000, which is (the) code for $999. <<long pause>> I am thrilled to announce to you that the iPad pricing starts not at $999, but at just $499!"*
>
> *– Steve Jobs*[26]

As the former CEO of Apple introduced the newly launched iPad back in 2010, he made sure to fully exploit the anchoring bias. This refers to people's tendency to place too much emphasis on the initial piece of information provided (the 'anchor') for subsequent judgments during decision-making. Once the anchor is determined, subsequent judgments will be calibrated using the anchor as a reference point. Consequently, the decision-maker will be biased towards interpreting subsequent information obtained around the anchor.

Sunk cost fallacy, in the case of military strategy, could result in the unnecessary protraction of wars due to fears that war-termination would result in wastage of the human lives, money and time previously expended.

By stating the 'initial' cost at $1,000, Steve Jobs anchored the audience's minds on the idea that an iPad costs approximately $1,000. When he subsequently announced the actual price, the audience felt that they had saved $500. If Steve Jobs had said, "We were thinking of pricing it at $399, but we decided to go for $499," the audience would certainly have felt that they were being swindled—although the actual iPad price would have been the same across the two scenarios.[27]

During World War Two (WWII), the British orchestrated a deception ploy, known as the Cyprus Defence Plan, which exploited the Germans' anchoring bias. With the Germans' capture of Crete, the British feared that the mere 4,000 soldiers on Cyprus would not be capable of defending against a German offensive. Therefore, the British implemented the Cyprus Defence Plan, which was intended to convince the Germans that 20,000 troops were stationed on the island. They achieved this by creating a false division headquarters, barracks and fleet of military vehicles together with fabricated radio communications. The British also distributed a phony defensive plan with maps, graphics and orders through double agents. The Germans were successfully deceived and were anchored on '20,000 troops', factoring this figure into their planning, for the remaining three years of the war. It is believed that the anchoring bias persisted despite their subsequent analysis that this figure could have been an exaggeration, attesting to the resistance of the anchor to subsequent information.[28]

SOLUTIONS

Cognitive biases impair our assessment of the probability of each cost and benefit materialising. This, in turn, impairs military decision-making at the strategic and operational levels. If we were to refer to the Observe–Orient–Decide–Act (OODA) loop, cognitive biases can exert their detrimental effects during the search ('Observe') and interpretation ('Orient') of data leading up to a decision, as well as, the decision-making process itself ('Decide'). The preceding sections have covered examples for this in depth.

Cognitive biases can be amplified by 'group-think', which is 'the practice of thinking or making decisions as a group, resulting typically in unchallenged and poor-quality decision-making'. Once the cognitive biases are combined with 'group-think', the biases remain uncorrected and there can be disastrous consequences.

Therefore, it is imperative for the SAF's operational staff to employ strategies that mitigate these cognitive biases, to allow for more accurate assessment of probabilities and therefore facilitate better decision-making.[29] These strategies would need to be grounded on an open culture, in which operational staff are encouraged to be honest about their views.

The following section describes how checklists, red teaming, games and fresh eyes can be employed to counteract cognitive biases at different stages of the Observe-Orient-Decide-Act (OODA) loop. Please refer to *Figure 1*.

Checklists

Checklists promote methodical thinking of issues. Some judges adopt this tool to promote comprehensiveness and objectivity as they rule on court cases, so as to counter cognitive biases.[30] Checklists are also used in the SAF when we evaluate our units,

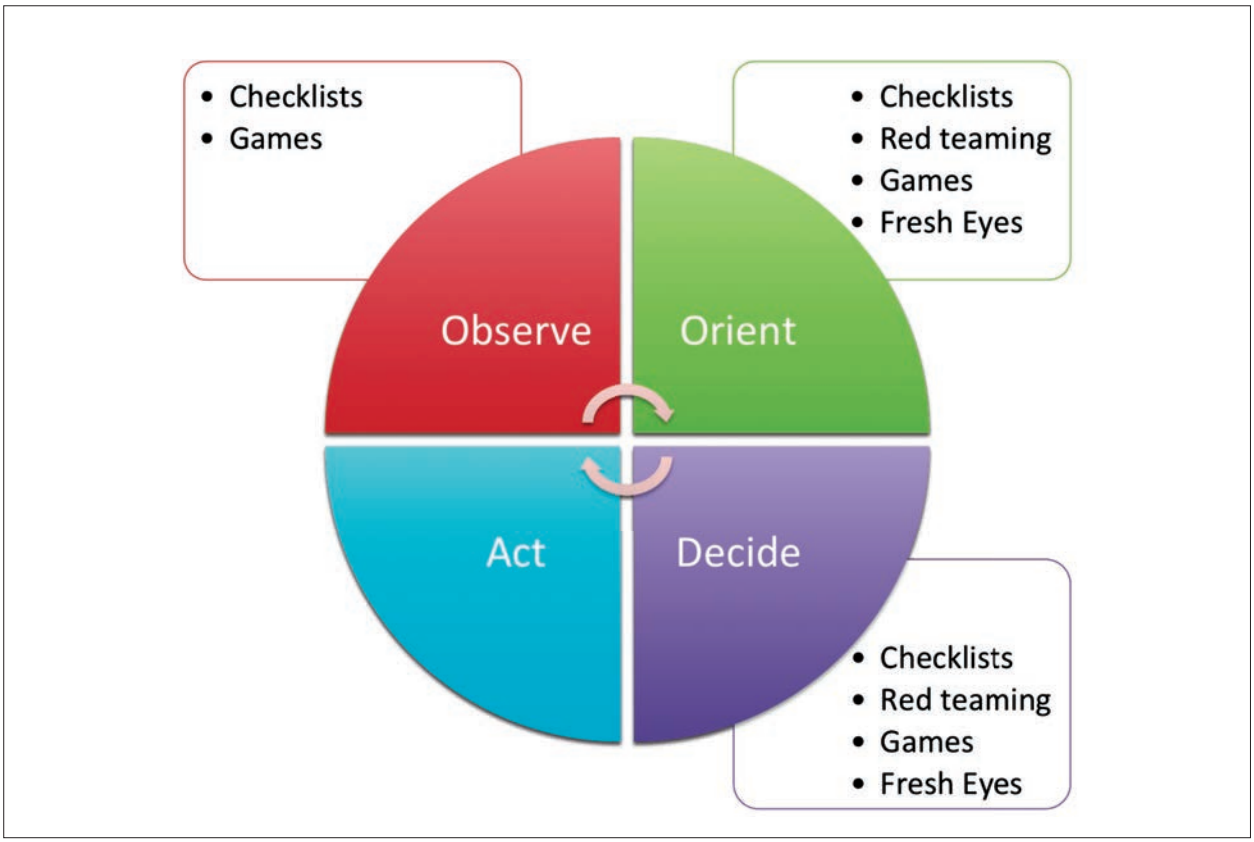

Figure 1: Strategies to Counter Cognitive Biases in the OODA Loop

prepare our forces for operations and make certain important financial decisions. Likewise, checklists can be used effectively in the SAF Command Post to counter cognitive biases throughout the 'Observe', 'Orient' and 'Decide' steps. In formulating and following checklists, the operational staff will be forced to comprehensively search for, list down and consider all relevant factors. The rigorously completed checklist will subsequently serve as a thorough guide for decision-making. It would include factors such as:

(1) Both salient and less salient events—The checklist should comprehensively include both recent salient events that support the working hypothesis, as well as other events that might be less salient but nonetheless relevant. In doing so, the operational staff would be less reliant on their memories and not be beholden to readily retrievable ones. They would therefore be less susceptible to the availability bias.

(2) Disconfirming evidence and alternative hypotheses—Other than supporting evidence, the checklist should also include disconfirming evidence that does not conform to the favoured hypothesis, as well as include alternative hypotheses. By systematically reviewing these factors, the operational staff can mitigate confirmation and disconfirmation biases.

Red Teaming

To overcome cognitive biases, there is a need to consider alternative hypotheses for the information at hand. However, research has demonstrated that people, on their own, are rather inept at generating such alternative hypotheses.[31] The SAF Command Post

could overcome this by institutionalising red teaming throughout the 'Orient' and 'Decide' steps. A red team, separate from the main operational staff, can be created to dedicatedly conceptualise viable alternative hypotheses to explain the data and to subsequently propose decision-making options.

President John F. Kennedy employed red teaming during the Cuban Missile Crisis. He split his staff into separate groups and designated his brother as the 'devil's advocate'. His advisors were therefore compelled to rigorously critique and defend their own assumptions and to creatively generate alternative responses to the crisis.[32]

Red teaming is also an approach adopted by established militaries. The United Kingdom's (UK) Joint Doctrine Publication 5-00, *Campaign Planning* lays out the purpose of red teams: "to challenge the perceived norms and assumptions of the commander and his staff."[33] Similarly, the US Army Training and Doctrine Command specially chartered a university to conduct a suite of red teaming courses for its commanders and staff.[34]

Alternative hypotheses generated by a red team will help prevent the main operational staff from ignoring contrary information (disconfirmation bias) and over-emphasising supporting evidence (confirmation bias). A formidable red team will also serve as a check against the excessive confidence of the main operational staff and also point out when sunk cost fallacies have been committed.

Games

The SAF has developed an array of simulation systems to create virtual scenarios for training purposes. Such systems, from single platform simulators to the Multi-Mission Range Complex, have proven to be effective in enhancing our servicemen's warfighting competencies. Similarly, simulation technology can be used to train up our operational staff's ability to counteract cognitive biases. For instance, Raytheon funded the design of a decision-making game that might help intelligence analysts detect and mitigate cognitive biases during their course of work. This game simulates scenarios based on actual situations that US intelligence analysts experienced in Iraq. These scenarios were developed from a compilation of digital documents and reports from theatre.[35] Similar simulation technologies can be applied to train our operational staff's ability to mitigate cognitive biases across the stages of the OODA loop.

Fresh eyes

To the extent that the operational staff aggregate data for decision-making over a period of time, they can be susceptible to the anchoring bias and confirmation/disconfirmation bias. To mitigate this bias, the SAF could institutionalise the requirement for an individual, who was not involved in the prior information analysis, to step into the process at the end of the data collection process (after the 'Observe' stage, before 'Orient'). His role would be to lend a pair of fresh eyes as he reviews all the information at once. We should expect this individual to be free from the anchoring bias because he would not have an anchoring piece of information to start with. We should also expect this individual to be free from the confirmation/disconfirmation bias. He would probably not have had a preconceived hypothesis and therefore would not have different thresholds of evidence.[36]

During the 'Decide' stage, another pair of fresh eyes can be engaged to review the findings from the data analysis process for sense-making—the 'Orient' Stage. Decision-making will be more objective as it will similarly be protected against the anchoring and confirmation/disconfirmation biases.

The SAF has previously employed the fresh eyes strategy for project development, in peacetime. On some occasions, major projects had been stalled due to a lack of new ideas—dynamism in thinking had probably been curtailed as the project members developed fixed hypotheses over time, reinforced by a plethora of cognitive biases. By establishing working groups to lend pairs of fresh eyes, the SAF had decisively broken such deadlocks. This solution of using fresh eyes need not be restricted to a peacetime developmental setting, but can also be used to mitigate cognitive biases within the operational staff of the SAF Command Post.

CONCLUSION

In assessing probabilities of costs and benefits, prior to making staff recommendations for options, our operational staff will be susceptible to a slew of cognitive biases. In combination with other contextual factors, cognitive biases have been shown to result in starkly inaccurate assessments and therefore poor military decisions at the strategic and operational levels. Therefore, the SAF needs to be cognisant of these biases and to implement strategies to counteract them.

While not discussed in this essay, it should be noted that cognitive biases also affect tactical decision-making. For instance, a slew of biases could affect a patrolling soldier's decision on whether a plainclothes man is a terrorist planting an IED or just an innocent civilian. Cognitive biases at the tactical-level can similarly be mitigated by the abovementioned strategies. However, this falls beyond the scope of the present essay.

Finally, cognitive biases might not always be to our detriment; taking a leaf from the Cyprus Defence Plan, we can also exploit our adversary's vulnerability to cognitive bias in our military strategy. The resulting concerted use of strategic and operational deception will bring us closer to attaining Sun Tze's concept of "breaking the enemy's resistance without fighting."[37]

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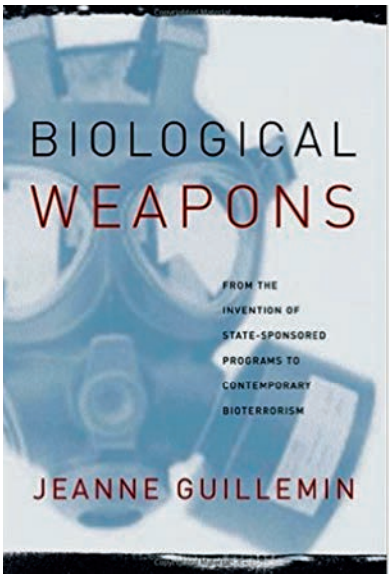
Book Review



Jeanna Guillemin, *Biological Weapons: From the Invention of State-sponsored Programs to Contemporary Bioterrorism, (New York, Columbia Word Press), 2002, 258 pages*

By **Delson Ong**

INTRODUCTION

Biological Weapons: From the Invention of State-sponsored Programs to Contemporary Bioterrorism spells out the evolution of the developments in biological weapons through the centuries, from the state-sponsored programmes in the twentieth century, to the existing threat of bioterrorism today. Covered in this book are the contributions made by several key figures in the field of biological and chemical weapons development and research, as well as their ideals and rationales for doing so. By bringing in historical context to our present day concerns of this issue, the bulk of the book's focus is about the programmes and protocols that existed in the past, both for and against the use of biological and chemical weapons during wartime. Throughout the book, the author provides the reader with a smooth flowing picture of the developments in the field of biological weapons from past to present, which would serve as an easy read for many readers.

The early chapters of the book cover the events before the existence of the first ever biological weapon in the world. Because of war, countries have been constantly searching for advancements in technology that would give them the edge they need in order to secure victory. Even before the first biological weapon was invented, numerous scientists had already begun to explore using biological weapons to achieve this very objective. With serious expectations of this possibility, countries like France, Japan, the United Kingdom (UK), the United States (US) and the Soviet Union have thus invested

a great deal of resources in the area of Research and Development in the field of biological weapons research. However, over the years, legal and technical restraints, civic awareness as well as the decisions of key political actors and military leaders have kept this innovative class of weapon from the destructive strategic uses that its advocates envisioned—the mass killing of non-combatants as a means to victory.

It is without any doubt that countries possessing biological and chemical weapons pose a huge threat to others, and this has accelerated the creation and development of major weapon programmes. Prior to World War One (WWI), aerial warfare and long-range bombers inspired many scientists to consider the fact that biological agents could be used in a similar way to devastate civilians with disease. However, biological weapons are considered a menace to civilians, no matter who owns it and hence, certain protocols were put in place to prevent the use of such weapons in warfare. The 1922 Treaty of Washington, although unsuccessful, became the template for the much more effective 1925 Geneva Protocol, which currently consists of 132 member state parties.[1] The protocol prohibits the use of chemical weapons in warfare and has since expanded its range to include the use of biological weapons as well. But due to the vagueness in terms of protocol, member states were able to utilise the biological and chemical weapons as a form of retaliation if they are first attacked by such weapons. This flaw in the protocol would come back to haunt those who support the cause, as many countries look to this as an excuse to be in possession of such weapons.

DOUBLE-EDGED SWORD

What makes biological weapons and agents so inherently dangerous is that troops needed to be protected against infectious disease agents that the enemy is going to use on them and at the same time, those that are being used by their fellow men. In a biological weapons programme by Frederick Banting, one of the uses of germs weapons he put forth was contaminated rifle bullets. The idea seemed legitimate at first, but on hindsight, the handling of these bullets complicates matters. It would be highly difficult to use due to the ease of contamination by the user, hence making this form of weaponry less favoured amongst soldiers.

However, the appeal of a biological and chemical weapon is not so much of it being different from the conventional arms that soldiers have been using. Rather, it lies in its ability to prevent the attacker from being seen, while still causing mass casualties. This application of scientific and technological knowledge is dubbed by many scientists as the 'humane alternative' to high explosives, which tears enemies limb from limb, as it avoids the battlefield blood and gore. From the military's point of view, biological weapons are mainly used to disorganise industrial areas behind the lines of army camps, or the camps themselves, resulting in huge losses of valuable plants, animals and food crops.[2] After all, defending soldiers against possible biological weapons attack is part of the mandate of all biological weapons programmes.[3]

Despite this, numerous political actors have stepped forward to voice their disapproval against using such weapons for warfare. President Franklin Roosevelt, a strong believer that biological and chemical weapons

were uncivilised, stood strong in his opinion that they should never be used at all. And, contrary to popular belief, military leader Adolf Hitler was on the same page as President Roosevelt as well. Although known for his ruthless killings by using poison gas, Hitler was averse to the use of such weapons. Others such as President Bill Clinton and Admiral William Leahy were also vocal in their opposition to weapons that were targeted at civilians.

If military and political leaders disapprove of using such weapons, why then do biologists and physicists devote their energies to developing weapons whose main target are civilians, with the sole purpose of taking lives?

In 1921, France began its first biological weapons programme, which was led by Auguste Trillat. Trillat, having conducted multiple experiments on airborne transmission of bacteria prior to his leadership stint, was keen on utilising France's retaliatory power as a form of defence, and has advocated the research on various germs and bacteria as potential candidates for weapons. However, much of Trillat's work in the programme was halted due to France's commitments to the Geneva Protocol and later destroyed when Germany occupied France in 1940.

In 1942, two American Biologists by the name of Theodor Rosebury and Elvin A. Kabat published a written document entitled 'Bacterial Warfare', and in it they described germ theory, the potentials of biological weapons as well as how to defend against them. Although it was written decades ago, the document is still widely discussed by scientists today.

The biologists, like Trillat, had the same sentiments about the airplane being the most useful means for dissemination of infective agents. But what made them different from Auguste Trillat was that the biologists believed that biological weapon research should be conducted for defensive purposes and deterrence, not as an offensive weapon. In their document, dubbed the 'Rosebury-Kabat report', they compiled a list of popular bacteriological agents that were suitable candidates for research. Taking into account host range, severity of symptoms and infectivity, Bacillus anthracis emerged on the top of the list as the most important agent for further research. Besides that, the list also briefly included diseases that were targeted at crops and animals. Rosebury and Kabat advised that experiments needed to be carried out on the listed agents to find out what they could do, and how to defend against them. They also warned, that should these pathogens be released into the outside world, it would be very difficult to check and eradicate.

Indeed, there were certain scientists who believed in both the offensive and defensive capabilities of biological weapons, and not just the former. Maurice Hankey was an influential civil servant during the inter war years, and had served as secretary to the British War Cabinet. It was because of him that the British did not confine themselves to purely defensive measures against biological warfare. Acknowledged as the founding father of UK biological weapons scientists, Hankey had a huge influence behind-the-scenes on the British defence policy as well. In 1938, the period of time when "politicians were obsessed with the problem of civilian casualties," Hankey took advantage of this obsession and turned it into what would be the

driving force for the creation of the Emergency Hospital Service in Great Britain. The service would eventually become an integral part of a postwar framework for nationalised healthcare.

Another figure to note would be Frederick Banting, a British medic from WWI and the founder of insulin which saved the lives of millions of diabetics. He too believed in the need for the British to establish themselves in the field of biological weapons both offensively and defensively due to the fact that Germany, Italy and Japan would wage war against Great Britain. Seeing the need to convince people who are capable of making a difference, Banting took the liberty of travelling to England after the German invasion, in hopes that he would be able to persuade influential scientists to start a biological warfare programme. And his reason for doing so—the Germans, having experimented on biological weapons, would not hesitate to use them should the need arise. Hence the UK should be prepared and armed with retaliatory powers of the same kind. Through the weapons programme that Banting created, he was able to evaluate treatments to counteract the biological agents, understand them and even predict the different ways of dispersing them. One of his findings includes the sending of bacteria via envelopes, which actually took place in 2001 in the US, shortly after the September 11 attacks.

PUBLIC HEALTH VS. BIOLOGICAL WEAPONS

The aims of public health are contradictory to that of biological weapons. For public health, the main goal is to discover and understand as much as possible about all the factors that cause diseases to spread, so as to break the causal chain and keep the civilians out of harm's way. On the other hand, biological weapons are all about developing diseases as a weapon, the reverse of the goals of public health.[5] This was illustrated in the years preceding WWII when public health advocates went one way, while civilian biologists of high calibre went on a distinctively different one. The advocates were concerned with promoting the general strengthening of British healthcare, because to them, it is only logical that the protection of civilians against biological weapons would be centered on public health reinforcement. On the other hand, the civilian biologists joined the military to develop biological weapons.

The final few chapters of the book covers present day issues about bioterrorism, with the area of focus largely on the US. Although there have been numerous protocols and policies erected to restrict the use of biological weapons, the effectiveness have been limited, particularly for the US due to their ignorance and inability to adhere to and abide by the terms. If the states were to exploit its scientific and technological prowess, it could pose as one of the most serious problems that humanity has ever faced. Moreover, without any pressure on member states of any given protocol to agree to verification measures, the opportunities for terrorists to attack would increase worldwide. It is therefore up to nations to come to a common consensus to improve their control of toxin and biological agents, a necessary component of international co-operation so as to ensure that they do not fall into the hands of terrorists. From a bird's eye view, there should be negotiations between nations to achieve a total ban of biological and chemical weapons.[6]

The presumption by the US that the threat of biological weapons is not apparent within its borders may be true, but the domestic crimes (such as the September 11 attacks and the anthrax letters attack shortly after) point to the fact that risks still exist within the country itself.[7] History tells us that without long term commitment and nonproliferation from member states, to achieve a set target would prove to be a daunting task. Right now, we are gambling with our future.

CONCLUSION

There may be little to no threats presented by biological and chemical weapons, but that does not give us the liberty to let our guards down. From the book, it is apparent that there is a new generation of biological weapons being developed. Indeed, the weapons are constantly evolving. And if pursued with vigour, these weapons could potentially make the US a technological powerhouse, especially when it comes to human control and domination. Despite the many differing viewpoints on biological weapons and its usage, the book is able to provide readers with a balanced viewpoint. It paints a clear picture of biological weapons development throughout the course of history, and by presenting both sides of the argument while constantly maintaining a neutral standpoint, this book is definitely an ideal choice for many readers.

ENDNOTES

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Nancy Wake (1912-2011)

by **Wu WenJie & Kayson Wang**

INTRODUCTION

Nancy Wake was a prominent figure in the *maquis*, the French Resistance during World War Two (WWII), and one of the Allies' most decorated servicewomen of the war. She played an important role in WWII, serving as a British Special Operations Executive (SOE) agent.

EARLY LIFE

Nancy Grace Augusta Wake, also known as Nancy Wake, was born in Roseneath, Wellington, New Zealand, on 30th August, 1912. Wake's father, Charles Augustus Wake, was a journalist and due to his career, the family had to move to North Sydney, Australia in 1914. However, her father returned to New Zealand, leaving her mother, Ella Wake to raise the children.[1]

In Sydney, she attended the North Sydney Household Arts (Home Science) School. At the age of 16, she ran away from home and worked as a nurse. After Wake turned 20, with £200 that she had inherited from an aunt, she journeyed to New York, then London where she trained herself as a journalist. In the 1930s, she settled in Paris and worked for the Hearst newspapers as a European correspondent. She witnessed the rise of Adolf Hitler and the Nazi movement and "*saw roving Nazi gangs randomly beating Jewish men and women in the streets*" of Vienna.[2]

WORLD WAR TWO

As the 1930s progressed, the rise of German Fascism formed the basis of many of Wake's stories. In 1935, she visited Vienna and Berlin where the overt and violent anti-Semitism movement formed in her a desire to oppose Nazism. In 1937, Wake met wealthy French industrialist Henri Edmond Fiocca, whom she married on 30th November, 1939, in Marseilles. Six months later, Germany invaded France. Wake and Fiocca joined the fledgling Resistance movement after France's surrender in 1940.

After the fall of France in 1940, Wake became a courier for the French Resistance and later joined the escape network of

Captain Ian Garrow. In a reference to Wake's ability to elude capture, the Gestapo called her the *White Mouse*. The Resistance exercised caution with her missions; her life was in constant danger, with the Gestapo tapping her phone and intercepting her mail.

In November 1942, Wehrmacht troops occupied the southern part of France after the Allies' *Operation Torch* had started. This gave the Gestapo unrestricted access to all papers of the Vichy *régime* and made life more dangerous for Wake. In the war, she was credited with saving the lives of hundreds of Allied soldiers and downed airmen between 1940 and 1943 by escorting them through occupied France to safety in Spain.

Her growing involvement in the Resistance saw Wake and her husband assisting in the escape of Allied servicemen and Jewish refugees from France into neutral Spain. By 1943, Wake was the Gestapo's most wanted person, with a 5 million-franc price on her head. When her network was betrayed that same year, she decided to flee Marseilles. Her husband, Henri Fiocca, stayed behind; he was later captured, tortured and executed by the Gestapo. In her attempt to flee, Wake had been arrested in Toulouse but was released four days later. An acquaintance managed to have her released by making up stories about her supposed infidelity to her husband. She succeeded, on her sixth attempt, in crossing the Pyrenees to Spain. Until the war ended, she was unaware of her husband's death and subsequently blamed herself for it.

Wake found her way to England and was accepted for training by the British Special Operations Executive (SOE), an intelligence group working with the French Resistance. Her colleague, Vera Atkins, who also worked in the SOE, recalls her as a "real Australian Bombshell."[3] Wake was known for her tremendous vitality and immense fighting spirit. Training reports record that she was "a very good and fast shot," possessed excellent field craft and was noted to have "put the men to shame by her cheerful spirit and strength of character."[4] After her training, Wake became a courier and then an escort for Allied soldiers and refugees trying to leave the country. "It was much easier for us, you know, to travel all over France," she told an interviewer for Australian television. "A woman could get out of a lot of trouble that a man could not."[5] Wake once described her tactics: "A little powder and a little drink on the way, and I'd pass their (German) posts and wink and say, "Do you want to search me?" Wake made use of her natural advantage as a woman and her charm to bypass many obstacles that a lot of men couldn't, which made her a very a capable agent.[6]

On the night of 30th April, 1944, when Wake was 31, she was among 39 women and 430 men who were parachuted into France to help with preparations for D-Day. Wake was parachuted into the Auvergne, becoming a liaison between London and the local maquis group headed by Captain Henri Tardivat in the Forest of Tronçais. Upon discovering her tangled in a tree, Captain Tardivat greeted her remarking, "I hope that all the trees in France bear such beautiful fruit this year," to which Wake replied with a firm tone, "Don't give me that French crap."[7]

Wake's duties included allocating arms and equipment that were parachuted in and minding the group's finances. Wake became instrumental in recruiting more members and making the *maquis* groups into a formidable force, roughly 7,500 strong. She also led attacks on German installations and the local Gestapo HQ in Montluçon.

At one point, Wake discovered that her men were protecting a girl who was a German spy. They did not have the heart to kill her in cold blood, but Wake did. After the war, Wake said that it was war, and she had no regrets about the incident.[8] Throughout the war, Wake helped establish communication lines between the British military and the French Resistance that were deemed crucial to weakening German strength in France in advance of the Allied invasion.

Once Wake was on a mission to replace codes her wireless operator had been forced to destroy in a German raid. She rode a bicycle for more than 500 kilometres through several German checkpoints. During a German attack on another *maquis* group, Wake, along with two American officers, took command of a section whose leader had been killed. She directed the use of suppressive fire, which facilitated the group's withdrawal without further losses.

From April 1944 until the liberation of France, her 7,000+ *maquisards* fought 22,000 Schutzstaffel soldiers (SS), a major paramilitary organisation under Adolf Hitler, causing 1,400 casualties, while suffering only 100 themselves. Her French companions, especially Henri Tardivat, praised her fighting spirit, amply demonstrated when she killed an SS sentry with her bare hands to prevent him from raising the alarm during a raid. After a period of training, Wake returned to France in April 1944 to help organise the Resistance before D-Day. Working in the Auvergne region, Wake was engaged in organising parachute drops of arms and equipment, and after D-Day, was involved in combat with bodies of German troops sent to destroy the *Maquis*.

During a 1990s television interview, when asked what had happened to the sentry who spotted her, Wake simply drew her finger across her throat. "They'd taught this judo-chop stuff with the flat of the hand at SOE, and I practised away at it. But this was the only time I used it—whack—and it killed him all right. I was really surprised."[9]

AFTER THE WAR

Immediately after the war, Wake was awarded the George Medal, the United States Medal of Freedom, the *Médaille de la Résistance*, and thrice the *Croix de Guerre*. Upon liberation, Wake finally learned that the Gestapo had tortured her husband to death in 1943 for refusing to disclose her whereabouts. In September 1944, Wake left the Resistance and went to SOE Headquarters in Paris, and then to London in mid-October. Shortly after, she worked for the Intelligence Department at the British Air Ministry attached to embassies in Paris and Prague.

Not long after, Wake returned to Australia and stood as a Liberal candidate in the 1949 Australian Federal election for the Sydney seat of Barton, running against Dr. Herbert Evatt, then Deputy Prime Minister, Attorney-General and Minister for External Affairs in the Ben Chifley Labour government. While Chifley lost the government to Robert Menzies, Wake recorded a 13% swing against Evatt, with Evatt retaining the seat with 53.2% of the vote on a two-party preferred basis. Wake ran against Evatt again at the 1951 federal election. By this time, Evatt was Deputy Leader of the Opposition. The result was extremely close. However, Evatt retained the seat with a margin of fewer than 250 votes.

Wake left Australia just after the 1951 election and moved back to England. She worked as an intelligence

officer in the department of the Assistant Chief of Air Staff at the Air Ministry in Whitehall. She resigned in 1957 after marrying an Royal Air Force (RAF) officer, John Forward, in December of that year. They returned to Australia in the early 1960s. Maintaining her interest in politics, Wake was endorsed as a Liberal candidate at the 1966 federal election for the Sydney seat of Kingsford Smith. Despite recording a swing of 6.9% against the sitting Labour member Daniel Curtin, Wake was again unsuccessful. Around 1985, Wake and John Forward left Sydney to retire to Port Macquarie.

LATER LIFE

In 1985, Wake published her autobiography, *The White Mouse*, which became a bestseller and has been reprinted many times.

After Wake's third failed attempt to enter politics, she and her husband John Forward ultimately retired to Port Macquarie, Australia where they lived until his death in 1997. The couple were married for 40 years and had no children.

In 2001, Wake left Australia for the last time and immigrated to London. She became a resident at the Stafford Hotel in St James' Place, near Piccadilly, formerly a British and American forces club during the war. She had been introduced to her first "bloody good drink" there by the general manager at the time, Louis Burdet.[10] He had also worked for the Resistance in Marseilles. In the mornings, she would usually be found in the hotel bar, sipping her first gin and tonic of the day. She was welcomed at the hotel, celebrating her 90th birthday there, where the hotel owners absorbed most of the costs of her stay. In 2003, Wake chose to move to the Royal Star and Garter Home for Disabled Ex-Service Men and Women in Richmond, London, where she remained until her death.

Wake had received the George Medal, 1939-45 Star, France and Germany Star, Defence Medal, British War Medal 1939-45, French Officer of the Legion of Honour, French *Croix de Guerre* with Star and two Palms, US Medal for Freedom with Palm and French *Medaille de la Resistance* for her courageous endeavours. Wakes' medals are now on display in the Second World War gallery at the Australian War Memorial.[11]

DEATH

Wake died on Sunday evening 7th August, 2011, age 98, at Kingston Hospital after being admitted with a chest infection. She had requested that her ashes be scattered at *Montluçon* in central France. Her ashes were scattered near the village of Verneix, which is near *Montluçon*, on 11th March, 2013.

Her obituary was included in and inspired the title for *The Socialite who killed a Nazi with Her Bare Hands: And 144 Other Fascinating People who died this Year*, a collection of New York Times obituaries published in 2012.[12]

PERSONALITY

Nancy Wake did not like killing people. But in wartime, she once told an interviewer, "I don't see why we women should just wave our men a proud goodbye and then knit them balaclavas."[13] When the Nazi's violence terrorised her city, those attacks made her promise herself that "if ever the opportunity arose, I would do everything I could" to stop the Nazi movement, for her "hatred of the Nazis was very, very deep."[14]

When it came to the war and her training with the SOE, Wake once said "I was never afraid," she said. "I was too busy to be afraid."[15] On a side note, Wake never figured out what to do with her life after the war. "It's

dreadful because you've been so busy, and then it all just fizzles out," she told an Australian newspaper in 1983.[16]

Wake kept on being an activist in WWII education even after her retirement and her attempts on joining politics shows that Wake has always been an enthusiast in making the world a better place, especially after what she had witnessed during the was. She led by example, not only as a woman, but also as a hero, which left a huge impact in the Allies victory in WWII.

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Quotable Quotes

Security is the foundation on which peace and prosperity is built.
Without it no nation can plan and build its future. Defence is commitment to the future.
– Goh Chok Tong (b. 1941), former Prime Minister and Emeritus Senior Minister of Singapore.

Peace is not absence of conflict; it is the ability to handle conflict by peaceful means.
– Ronald Reagan (1911-2004), 40th President of the United States.

Live as if you were to die tomorrow. Learn as if you were to live forever.
– Mahatma Gandhi (1869-1948), Leader of India's independence movement.

If your actions inspire others to dream more, learn more, do more and become more, you are a leader.
– John Quincy Adams (1767-1848), 6th President of the United States.

Well, in the first place, military service, they don't call it service for nothing.
You are actually serving your country. And it is a worthy and valid vocation.
– Richard Duane 'Rick' Warren (b. 1954), American evangelical Christian Pastor and author.

We are drowning in information but starved for knowledge.
– John Naisbitt (b. 1929), American author and public speaker in the area of future studies.

You teach best what you most need to learn.
– Richard David Bach (b. 1936), American writer.

The starting point of all achievement is desire.
– Napoleon Hill (1883-1970), American author and impresario.

If you're not making mistakes, then you're not doing anything.
I'm positive that a doer makes mistakes.
– John Robert Wooden (1910-2010), American basketball player and coach.

Strive not to be a success, but rather to be of value.
– Albert Einstein (1879-1955), theoretical physicist.

Circumstances are beyond human control, but our conduct is in our own power.
– Benjamin Disraeli (1804-1881), British politician and writer.

Education is a weapon whose effects depend on who holds it in his hands and at whom it is aimed.
– Joseph Stalin (1878-1953), former leader of the Soviet Union.

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For example:

Tim Huxley, *Defending the Lion City: The Armed Forces of Singapore* (St Leonard, Australia: Allen & Unwin, 2000), 4.

Huxley, *Defending the Lion City,* 4.

Ibid., 4.

Edward Timperlake, William C. Triplett and William II Triplet, *Red Dragon Rising: Communist China's Military Threat to America* (Columbia: Regnery Publishing, 1999), 34.

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For example:

Chan Kim Yin and Psalm Lew, "The Challenge of Systematic Leadership Development in the SAF," *POINTER* 30, no. 4 (2005): 39-50.

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Articles in Newspapers

Citations should include the author, title of the article (quotation marks), title of newspaper (italicised), date of publication, appropriate page reference, and URL in the case of e-books.

For example:

David Boey, "Old Soldiers Still Have Something to Teach," *The Straits Times,* 28 September 2004, 12.

Donald Urquhart, "US Leaves it to Littoral States; Admiral Fallon Says Region Can Do Adequate Job in Securing Straits," *The Business Times Singapore,* 2 April 2004, 10.

Online Sources

Citations should include the author, title of the article (quotation marks), name of website (italicised), date of publication, and URL. If no date is given, substitute date of last modification or date accessed instead.

For example:

Liaquat Ali Khan, "Defeating the IDF," *Counterpunch,* 29 July 2006, http://www.counterpunch.org/khan07292006.html.

If the article was written by the publishing organisation, the name of the publishing organisation should only be used once.

For example:

International Committee of the Red Cross, "Direct participation in hostilities," 31 December 2005, http://www.icrc.org/Web/eng/siteeng0.nsf/html/participation-hostilities-ihl-311205.

If the identity of the author cannot be determined, the name of the website the article is hosted on should be used. For example:

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