Technology—Boon or Bane?

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Abstract:

The utility of technology in the military context has grown at a ubiquitous rate, from raw firepower to warfare support systems and logistic environments. Rapid development of technology has allowed the military to expand the capabilities and aptitude of its forces by a pronounced extent in the past half a decade. As a result, the military has become increasingly reliant on technology and there is a need for sufficient and effective management structures to prevent an emergency in the event that technology fails us. Thus, we can see that technology can be a double edged sword; it can be a formidable instrument or a life-saving mechanism in times of crisis or a possible perilous shortcoming if mismanaged or not used to its fullest advantage.

Keywords: Management, Technology Roadmap, Technology Advancement, Technology Management

INTRODUCTION

> *"God fights on the side with the best artillery."*
>
> *Napoleon Bonaparte*[1]

Military technology has evolved continuously through the ages to improve the mobility, firepower and protection of troops. We have seen the evolution from cavalry to unmanned vehicles, from gunpowder to guided weapons and from bronze shields to composite armour. Through the years, we have seen militaries competing in the arms race and showcasing the latest technologies and latest weapons. Since the early 1900s, technology has dominated warfare and may have contributed to 190 million fatalities during the 25 biggest conflicts of the 20th century. However, is the constant introduction of technology only a surface solution or can it really elevate a military over its adversaries? This essay will explore the pros and cons of the constant introduction of technology and discuss how technology should be introduced and managed in the military context.

ADVANTAGES OF TECHNOLOGY

Technology has often been the cornerstone of many militaries and has been wielded by many countries to gain a decisive victory in conflicts. The advantages that technology can provide to the military include the following:

Maintain Capability Superiority

The main advantages would be for the country to maintain its capability superiority over its potential adversaries and to ensure its swift and decisive response to any potential threats. At the same time, this may reduce combat losses of lives and equipment. An example of this was in the Persian Gulf War, which was won by the Coalition forces in a short time—a ground attack which lasted 100 hours in February 1991. This was due to the technological sophistication of United States (US) weapons and logistic support systems.[2]

Technological Surprise

All militaries need to create technological surprises to its adversaries as well as to conversely prevent

being technologically surprised. New, cutting-edge technologies can be an ace in the hole which, when unleashed, can potentially tip the outcomes of conflicts. One of the most famous examples would be the dropping of the atomic bombs on the cities of Hiroshima and Nagasaki on 6th and 9th August, 1945 by the US, which marked the end of the Second World War (WWII).[3]

Showcase Military Presence

Besides the obvious showcasing of military might, technology helps to create a credible military presence. The government would want to exhibit the country's continual commitment to defence and to establish a secure environment in the country. Technology further serves as a deterrence to potential aggressors. News coverage on military exercises frequently reports the use of new technology not only to showcase it, but to also showcase its successful usage during the exercises. An example of this was in 2008 when Russia conducted the month-long Exercise Stability, in which it showcased many of its technological developments such as its supersonic strategic bombers, warhead technologies and naval technologies, and so on.[4]

Create Tactical Options

With the constant introduction of technology, there are more options available for the military leaders to counter various threats. As warfare becomes more asymmetric, threats come in many forms and are more likely to be unexpected and highly complex. As asymmetric threats become more protean, the adaptability to the various forms of threats is crucial and having a platter of technology options is definitely one of the possible choices.[5]

Employment Opportunities

While employment opportunities might not be what is usually intended, with the constant introduction of technology, there is a need to sustain it and it opens opportunities for employment. It has been reported, "In the United Kingdom alone, some 350,000 people are employed—with over 10,000 companies partly or fully involved in the defence industry."[6]

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Technology as a Force Multiplier

For nations with limited resources, an example being Singapore, technology is able to provide the qualitative edge. Technology can be used to help automate and computerise as many processes as possible to enhance efficiency and to reduce the manpower required to undertake the processes.[7]

DISADVANTAGES OF CONSTANT TECHNOLOGY INTRODUCTION

While technology can provide the aforementioned advantages, there are corresponding disadvantages such as the following:

High Cost of New Technology

Cutting edge technology is expensive and the resources required to sustain and manage it, could easily be many times its capital cost. If not controlled, the cost of the technology may potentially spiral upwards. With finite budgets, the people of the country must clearly see its need. One mistake commonly made is that new technologies are purchased even when enough time has not been used to explore how to best utilise technology already installed.[8]

Constant Training and Doctrine Revisions

With the continuous evolution of technology, there is a need to adjust and maintain different doctrines as well as to cater many sets of training. This might lead to confusion as well as unsettle the rhythm of training. Furthermore, while technology makes performing the intended tasks easier, the training required to attain the necessary level of competency may be more difficult with the introduction of technology.

Rapid Obsolescence

As militaries adopt technology for the long term, they typically procure proven technologies. However, as can be seen in *Figure 1*, the rate of technological obsolescence increases as it becomes more rapidly adopted. This means that by the time the technology is fully operationalised, it may no longer be effective against the threats that would have evolved during the same period.

Overriding Human Psychology

It is sometimes important to think about not just technical feasibility but also operational utility. This is an important factor especially when dealing with humans who have phobias, preferences and tendencies. An example of human psychology coming to play comes from the low rate of beyond visual range kills made for air combat from 1965 to 1982, even though technical capability was available. The overriding constraint was actually not a technical one but a matter of compelling human preference. Many of the pilots were reluctant to shoot unless they were virtually certain that the target on the radarscope was not that of a friendly aircraft.[9]

Over-Reliance on Technology

One valid fear of the adoption of technology is an over-dependence on the technology by the users themselves. This poses two important questions:

1) How proficient is the User?

Technology is only as effective as its user. As we become more dependent on technology, particularly in the area of communications and surveillance, human errors may still cause information to be interpreted incorrectly, especially during high-tension combat situations. An example would be the Iran Air Flight

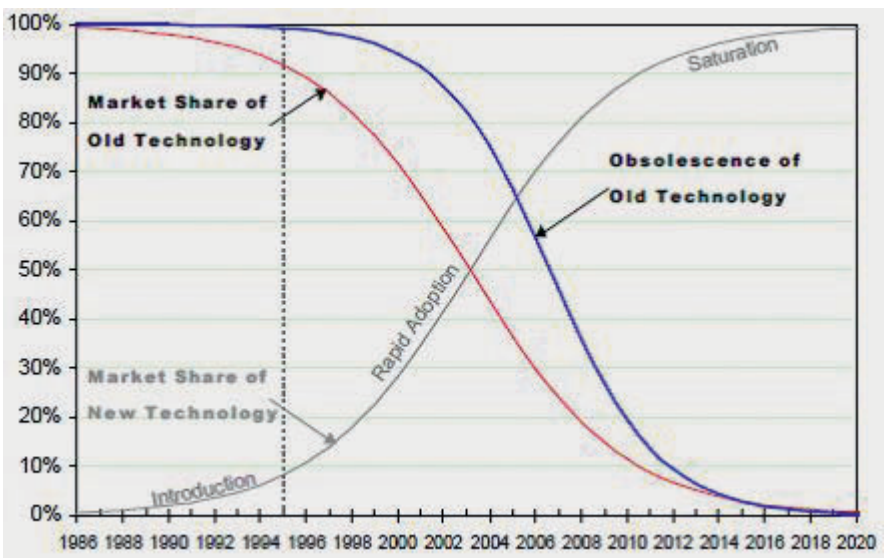

Figure 1: Chart Showing the Rapid Obsolescence of Technology with Time.[10]

655 incident in 1988, during which the crew of the *USS Vincennes* misidentified the flight path of the ascending commercial airliner as a descending one, similar to that of the fighter aircraft, resulting in the commercial airliner being shot down by mistake.

More often than not, new technology requires more energy and power. With the depletion of natural resources, militaries may be hard pressed to decide how to manage their energy and power resources

2) What to do When Technology Fails?

Despite the strengths of technology, it still cannot match against the ingenuity of the human mind, which is able to come up with innovative solutions to outsmart a more technologically-advanced military. During the Millennium Challenge 2002, a major war game exercise conducted by the US Armed Forces, the opposing Red force "used motorcycle messengers to transmit orders, negating Blue's high-tech eavesdropping capabilities."[11] After a series of similar low-tech tactics, Red seriously crippled Blue, causing the exercise to be reset. Red was forced to follow a scripted set of actions, thus resulting in accusations by the Red commander that the entire war game was scripted to ensure an American victory. Thus, this stresses the importance of having sufficient foundational proficiencies and backup plans to counter any failures of technology.

Figure 2: Combat Information Centre on board the USS Vincennes.

Logistics Issues

Many logistics issues abound with the continuous introduction of technology. They are predominantly listed as follows:

(1) Spares Stockage

With a continuous introduction of technology and systems, there is a need to ensure the sustenance of systems with spares availability.

(2) Inability to Sustain Operations & Support (O&S) Capability

O&S capability requires time to build up as well as to stabilise.

(3) Build-up of Local Technology Capability

Besides O&S capability, the capability to upkeep and enhance the systems is required, especially for a home grown technology to avoid long lead times and low availability. Establishing local technology capability would require manpower, plants, equipment, financial investment and adequate supporting defence industries.

(4) Manpower adequacy

In lieu of security reasons, local manpower would be required to manage and use the technologies. As such, there is a need to compete with the local industries for finite human resources.

(5) Infrastructure Requirements

Firstly, there would be the requirement of infrastructure to house whatever new technology is introduced. Secondly, infrastructure would be required to enable training as well as continuous tests and evaluations.

Energy and Power Resources

More often than not, new technology requires more energy and power. With the depletion of natural resources, militaries may be hard pressed to decide how to manage their energy and power resources. As aptly quoted from the Power and Energy Strategy White Paper by the US Army in 2010, "In order to consistently prevail, we must maintain the technology edge across the board, perpetuating the energy challenge."[12]

Deployability of Military Technology

While commercial off-the-shelf technology may be possible to be deployed for defence uses, the converse is usually not true. As such, many of the unused technology may fade into oblivion. Another obvious impact would be the financial burden placed by continuing to maintain obsolete technology that cannot be transferred to other uses.[13]

TECHNOLOGY MANAGEMENT

Technology Planning Process

So what do we need to put in place so as to introduce technology? It is important to put in place a plan to identify, develop and introduce technologies that can meet their intended mission. The Technology roadmap is one such plan that assists in making technology investment decisions by identifying critical technologies and technology gaps; and identifying ways to make use of investments from R&D. The technology road mapping process comprises three stages: (1) preliminary activity, (2) development of the technology roadmap and (3) follow-up activity:[14]

Preliminary activity include: (1) Satisfy essential conditions, (2) Provide leadership/sponsorship and (3) Define the scope and boundaries for the technologu roadmap.

It is important to put in place a plan to identify, develop and introduce technologies that can meet their intended mission.

Development of the technology roadmap includes: (1) Identify the 'product' in the roadmap, (2) Identify the critical system requirements and their targets, (3) Identify the main technology areas, (4) Specify the technology drivers and their targets, (5) Identify technology alternatives and their time-lines, (6) Recommend the technology alternatives that should be pursued and (7) Create the technology roadmap report.

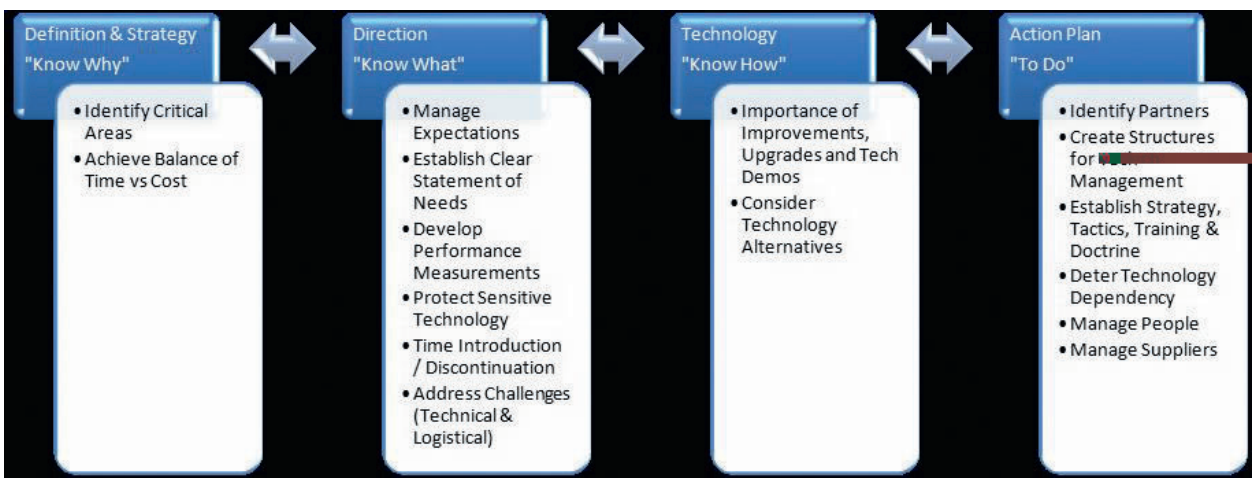

Figure 3: Technology Capability Roadmap.[15]

Follow-up activity includes: (1) Critique and validate the roadmap, (2) Develop an implementation plan and (3) Review and update.

Technology Roadmap

The outcome of the aforementioned process is a Technology Roadmap which is driven by a need and helps to identify the technologies to address this need. An iterative Technology Roadmap with four stages as recommended by the Albright Strategy Group and adapted for technology management is shown in *Figure 3* with all the possible considerations explained in the following paragraphs.

Know Why

This segment defines "the domain of the roadmap, the team's objectives and their strategy for achieving those objectives – the "why" of a roadmap. The roadmap's definition and strategy often include market and competitive assessments as well as planned applications."[16] Under this segment, the team needs to perform the following:

(1) Identify Critical Areas

It is not viable for any organisation to master all technologies due to finite resources and economies of scale. As such, there is a need to identify critical areas to carve a niche in. After identification, the portfolio can then be adequately grown.

(2) Achieve Balance of Timing Vs Cost

There is a need to balance the timing of new technology to strike a balance between having a new technology and the cost to sustain it. Adopting new technology is slow because it is usually expensive, unfamiliar and imperfect, as compared to old technology which has economies of scale, stable and has been widely used.[17] This is usually depicted by the Fisher-Pry model's S-curve shown in Figure 4. The cost usually seems tolerable during the development phase. However, once fielded, there may be unforeseeable high costs required for sustenance, which forms an important consideration.

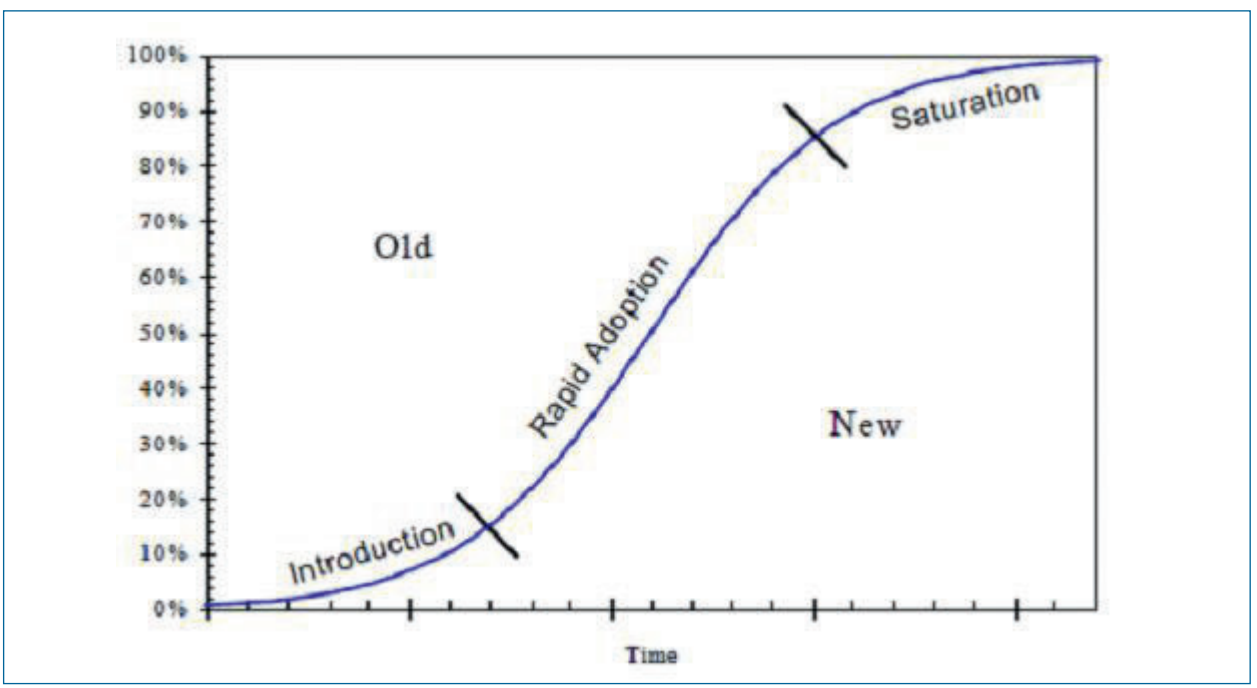

Figure 4: Fisher-Pry Curve.[18]

Know What

This segment defines "the direction, or the team's plans – the "what" of a roadmap. The direction includes challenges, the architecture and evolution of the team's solution and measurable performance targets to achieve the objective."[19] It is important that the team addresses the following:

1) Manage Expectations

It is important to manage the expectations and recognise the limitations of technology and not be too ambitious. The US Department of Defense's failure in the Future Combat Systems Programme was because "it was too ambitious and not executable within reasonable technical, engineering, time or financial resources."[20]

2) Establish Clear Statement of Needs

Besides limitations, there is the requirement to balance the military's needs versus the technology options. Though there are many technologies that might seem 'sexy', the basic justification is whether there is a need to adopt them.

3) Develop Performance Measurements

Just like other technologies, there is a need to evaluate their performance and it is imperative that performance-based metrics are developed to objectively assess operational effectiveness as a function of time.[21] Besides assessing performance, such measurements can help us decide on the continuation or termination of the programmes. Performance measurements can even be used to measure a technology through its evolution as shown in *Figure 5*.

4) Protect Sensitive Technology

To enable technology superiority, adequate safeguards have to be established to protect sensitive technology. Such a challenge was faced by the US Department of Defense in 2007 when a defence contractor illegally sent classified military information to other countries such as China. The defence contractor was apprehended and had to pay a $100 million penalty.[23] In this case, although the contractor was made to pay, the damage had already been done through the sharing of confidential information. The challenge in the protection of sensitive technology is even more pronounced in this cyber-age where higher connectivity and greater computing power is more accessible to the average person. This was experienced by the Pentagon in the spring of 2011 when "it suffered one of its largest losses ever

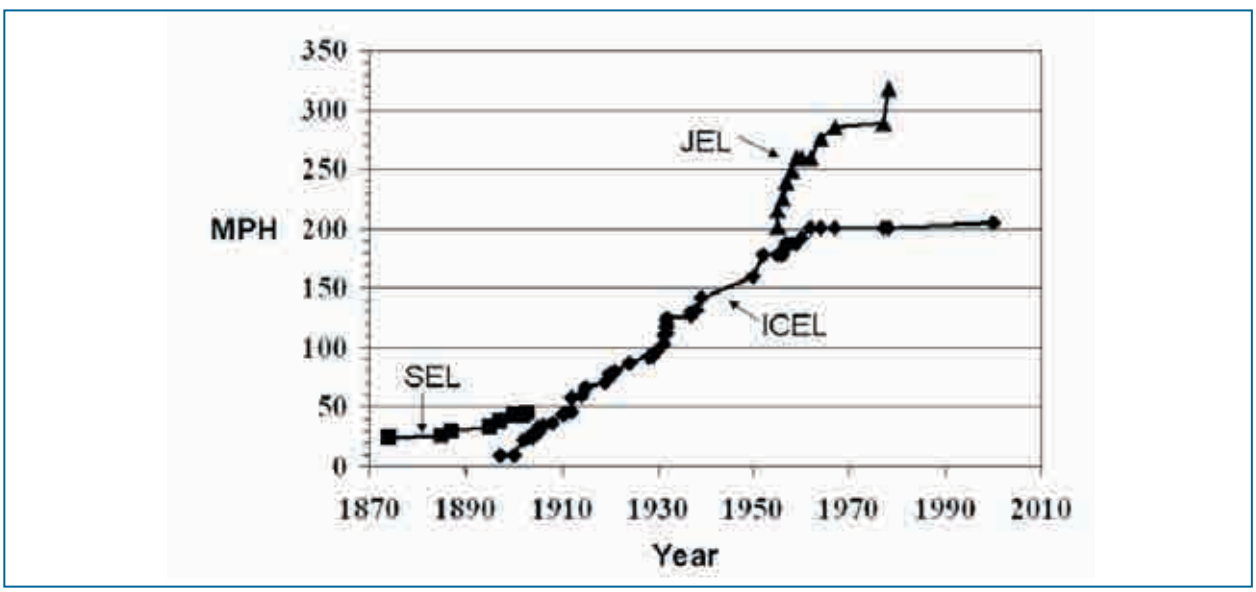

Figure 5: Performance measurements of three distinct technological 'lineages' over time: the Steam Engine Lineage (SEL), the Internal Combustion Engine Lineage (ICEL), and the Jet Engine Lineage (JEL).[22]

of sensitive data in a cyber-attack by a foreign government."[24] Such attacks also show that the military's vulnerability extends beyond its own computers. A pilot programme was therefore launched by the Pentagon to share classified threat intelligence with a handful of companies to help them identify and block malicious activity.[25]

Figure 6: People using the wireless Internet in a coffee shop.[26]

5) Timing of Introduction / Discontinuation

Time is of the essence in the introduction of technology and any mature or applicable technologies that can be moved to the field may make an immediate impact as a disruptive technology. Fielding the innovation is where most emerging technologies have the greatest transitional roadblocks to surmount.[27] However, the pace of technology change may also mean obsolescence and committing too much to an immature technology too early, are real risks. There have been many examples of defence equipment programmes "that have attempted to incorporate technology that was needlessly ahead of its time, yet because of consequential delays, ended up being obsolete before entering service."[28] There may be a need to allow for time to stabilise new technology before introduction. Vice versa, there may also be a need to consider when to discontinue a technology if it is not viable rather than to continue investing.

Figure 7: Forced introduction of Technology.[29]

(6) Address Technical Challenges

In principle, though the defence sector can draw from a very wide technology base, there is some degree of isolation. Not all general technology base flows into defence applications with equal ease.[30] Thus, adjustments must be made to enable the technology to be adapted for defence purposes. It is also paramount that improvements or changes are made accordingly, as technology is not a solution itself. Some militaries may try to circumvent this by buying commercially off-the-shelf. While this option allows getting the technology faster and cheaper off the shelf, the obvious disadvantage is that commercial products usually cannot meet military requirements. They may also lose their technological surprise as commercially off the shelf products are available to all.

(7) Address Logistics Challenges

Some may even have significant effects on the logistic supply chain and on the integrated logistic

support. New introductions may require new forms of supports such as manuals, additional inspection, test equipment etc. The operating service may "have to manage a heterogeneous array of modified and unmodified weapon systems representing different levels of upgrade and to maintain parallel logistic supply chains."[31]

Know How

The third segment describes "the evolution of technologies that will be used to achieve the objective – the 'how' of a roadmap. The 'technology roadmap' defines the technologies that will be used to implement each part of the architecture."[32]

1) Consider Technology Alternatives

As in all programmes, there is a need to consider and contrast technology alternatives so as to decide on the appropriate technology to adopt. After establishing their underlying principles and features, there is a need to critically examine their strengths and weaknesses, opportunities and challenges as well as their readiness levels.

2) Importance of Improvements, Upgrades and Technology Demonstrations

Even with the most advanced technology, there is a need to make pre-planned improvements to upgrade the technology. This provides a lower cost and faster alternative to new system development. At the same time, it is critical to have technology demonstrations to remove either overemphasis on an unproven technology or unwillingness to accept a viable technology. It is however noteworthy that too much technology demonstrations may impede the progress of technology development.[33]

To Do

The fourth segment defines "the action plan and risks - the 'to-do's' of a roadmap. The action plan identifies key development actions, resources required, risks and technology investment strategy"[34] as described in the following paragraphs:

1) Identify Partners

For sustenance as well as to harness the expertise external to the organisation, there is a need for the organisation to identify partners both in the local industries and for international collaboration. Partnerships can also allow complex technologies to be developed and moved forward more quickly.[35]

2) Create Structures for Technology Management

There is a need to create the appropriate structures within the organisation to manage the different technology portfolios. This would require structures to enable defence research and technology development as well as corresponding acquisition structures.

3) Establish Strategy, Tactics, Training and Doctrine

Some of the biggest changes would come at the strategic level where militaries make alterations to its military strategies in accordance to its technological capabilities. In WWII, the cause-and-effect relationship between military technology and strategy was clearly illustrated by the Germans decision to adopt the Blitzkrieg strategy with the advent of the tank.[36] Some technology introduction may also demand modifications of service's doctrine and accompanying revisions of operational training. This would be in terms of training, doctrine and tactics. This is important, as old training and doctrine are unlikely to make the most of new hardware.

4) Deter Technology Dependency

The growing dependence on technology may create unintended over-reliance. There is therefore the need to deter this. At the same time, they may create unintended consequences. A classic example would be the Yom Kippur War in 1973, in which the Israeli military possessed superior technology. This led to Israel's military and political leaders believing that they were 'invincible'. Surprise attacks by both Egypt and Syria on 6th October,

1973 put Israel's survival in jeopardy as it was woefully unprepared. Israel was fortunate that it still managed to turn the tide.[37] Another example is the growing reliance on high-tech systems that require huge information networks that could be high potential targets for potential adversaries. With the intertwining of these networks with the civilian populace, strikes on the military information networks may seed chaos in the home front. Another case in point would be in 2010 when a glitch in military GPS systems rendered as many as 10,000 United States (US) military GPS receivers useless for days. This dependency emphasises the need to protect technology.[38]

(5) Manage People

People recruitment and retention is always an issue for most organisations. In terms of recruitment, while hiring continuity would be preferred, there might likely be a smaller pool to start off with, as some scientists and engineers prefer not to do defence-related work. Furthermore, in an organisation that needs to protect technology, there are inherently many restrictions. As such, people retention might be a concern and a frequent change of staff would inhibit its growth and management of technology.

(6) Manage Suppliers

When introducing technology, the challenge is in the management of suppliers. Firstly, there is the challenge of having adequate supplier support. Studies have shown that many commercial suppliers find that the military is often a customer that is too costly to pursue for commercial purposes.[39] Conversely, there is the need to ensure non over-reliance on any one supplier and to have a stable of reliable suppliers. But it should not come to a point in which there is a need to balance having too many suppliers such that it becomes tedious in managing them.

CONCLUSION

As highlighted, technology can aid any military; however, it can also be an *Achilles Heel* if not carefully handled. As mentioned by Van Creveld in his book *Technology and War: From 2000 B.C. to the Present*, "The greatest victories that have been won in war do not depend upon a simple superiority of technology, but rather on a meshing of one side's advantages with the other's weakness so as to produce the greatest possible gap between the two."[40] We must therefore understand the various changes driven by technology and evolve accordingly as well as seize the right opportunity. Though technology can help us in many ways, especially in regards to offsetting reductions in size, it will not solve all the problems associated with war.[41] It is paramount that planning is done thoroughly before technology is introduced to reap the intended benefits.

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