FIRES

TEMPERING OF STEEL

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FIRES

TEMPERING OF STEEL

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“This book is dedicated to the men and women who have served in the Singapore Artillery.
Once a Gunner, Always a Gunner.”

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FOREWORD BY THE CHIEF OF DEFENCE FORCE

The SAF has come a long way in our transformation into a Third Generation fighting force. We have built upon the strengths of each Service to forge stronger cooperation and interdependence across the SAF. Precision weapons, unmanned systems and Integrated Knowledge-based Command and Control (IKC2) technologies were identified as three key areas of growth, and we have made significant progress in all of them. Our vision is to be a more integrated and networked SAF, one that is steadfast in our mission to enhance Singapore's peace and security through deterrence and diplomacy, and should these fail, to secure a swift and decisive victory over the aggressor.

The Singapore Artillery, more fondly known as the Gunners, has made bold and significant contributions as part of the SAF's transformation journey. Often lauded as a dominant player in land warfare, our Gunners have positioned themselves to shape the air-land battle space in support of SAF campaigns. Amidst an increasingly complex battlefield, the Gunners are now able to harness the full suite of sensors and shooters to orchestrate and deliver Joint Fires. This was made possible by steady investments in our strike capabilities, networked systems, and training development. Above all, the professionalism and commitment of our people remains the key to mission success. With outstanding Gunners possessing an indomitable Gunner's spirit and who fly our flag high even in far-flung places such as Afghanistan, I am confident that the Singapore Artillery will continue to add to its proud heritage.

This monograph captures the Gunners' reflections on their evolution thus far. It highlights the important work done in sharpening our strike capabilities and looks at the future trajectory of fires. I am especially delighted that many young Officers have contributed to this monograph. It certainly bodes well for the future of our Gunners and our Army when our younger Officers are passionate and take ownership of what they do.

I hope you will enjoy this monograph, and I wish the Gunners every success in the future.

In Oriente Primus.

LG NG CHEE MENG
Chief of Defence Force

FOREWORD BY THE CHIEF OF ARMY

At every level, military commanders guard their Artillery jealously—and there can be little wonder why—for on land the Artillery is unmatched in its range and firepower. Its ability to influence the outcome of major land offensives has been demonstrated on numerous occasions in contemporary battles and remarked upon by history's greatest military strategists.

The role of the Artillery in land warfare continues to evolve. Today, the Artillery has expanded far beyond its traditional role of supporting maneuver forces. Advances in munitions guidance and delivery, target mensuration and strike processes have collectively reshaped the applicability of Artillery in modern warfare. By reaching deep across the battlefield, well-orchestrated Artillery fires are a means to deprive the enemy of operational flexibility early in a land campaign and render his maneuver forces ineffective long before they close with one's own. In addition, our operating environment has also become more complex, and with it comes a new set of challenges that the Artillery must boldly confront. Competencies in areas such as target discrimination, management of effects and even ethical reasoning will need to be honed for the Artillery to operate effectively in tomorrow's battles.

This monograph will provide any reader a keen appreciation of the Artillery's influence on the battlefield and its future trajectory. That so many young officers have had a hand in authoring the essays that follow is a clear indication to me that the Singapore Artillery is well placed to continue its success when stewardship eventually passes to its next generation of leaders.

I congratulate the Singapore Artillery on the publication of this monograph "Fires" and look forward to its continued contribution to Our Army's mission.

King of the Battlefield.

MG RAVINDER SINGH
Chief of Army

PREFACE

In 2013, the Singapore Artillery celebrated its Centenary Silver Jubilee. Throughout our proud history, the Singapore Artillery has continually strived to innovate and excel in the face of evolving challenges. Although there have been various efforts in the past to capture the essence of our history and people in writing, it is timely to bring together our people and capture their thoughts of our present and, more importantly, our future. This *Fires* monograph was thus conceived.

The direction for the monograph was simple: "Let the future leaders of the Artillery Formation own this piece of work with the necessary latitude to express their thoughts." A group of young Gunners stepped forward and embarked on a journey to research and pen down their thoughts on a series of disciplines that they felt were important for the Singapore Artillery.

Fires is a consolidation of thought essays on various Artillery-related disciplines, arranged into three chapters. The first chapter provides a brief overview on the evolution of the Artillery and the effects that one can expect to achieve with fires. The second chapter deals with fires in the modern battlefield by providing in-depth discussions on two major contemporary disciplines: "Accuracy and Precision" and "C4ISR-Strike." The third chapter on "Future Fires" introduces some ideas and concepts in the area of technology, training, ethics and people for the Artillery Formation to ponder for the future.

Although the monograph is arranged thematically into Past, Present and Future, it is not the intention for the reader to read the monograph sequentially from cover to end. The reader may choose to start with any essay that interests him or her, as each essay is unique in its own right and examines the various disciplines of fires.

It is the sincere hope of the team that the reader will be provoked by the thoughts expressed in the writings, to debate on the challenges facing the Singapore Artillery, and the great opportunities and bright future that lie ahead for the Formation.

We hope you find this monograph a good read.

Once a Gunner, Always a Gunner!

COL TERRY SIOW
Chief Artillery Officer
March 2014

EVOLUTION OF FIRES: HOW FIRES CAN STAY RELEVANT ON THE MODERN BATTLEFIELD

By **CPT Edwin Lee Wen Jun** and **LTA Kwan Siew Ling**

ABSTRACT

The evolution of fires goes back many centuries. Trench warfare in WWI saw the improving technical design and capabilities of field artillery magnify its lethality on the battlefield. As technology advanced, field artillery started to employ computers for precision. The Singapore Artillery first started by building on its platform-centric capabilities and eventually evolved to become a critical system of the Singapore Armed Forces strike capability. Today, the fires paradigm has shifted to one that is driven by processes, coping with the complex environments and leveraging on complicated systems across Services. The role of fires has evolved from one of providing fire support, to being an essential capability employed to deliver operational and strategic effects.

INTRODUCTION

The role of fires has evolved from one of providing fire support at the tactical level to being a key capability employed to deliver operational and strategic effects in the battlefield. In this essay, "fires" is defined as the organization of sensor and shooter systems, as well as the associated personnel and supporting functions, to deliver lethal and non-lethal effects on land.

Fires began with a platform-centric focus to develop capabilities and expertise in the early years of the Artillery. It then adopted a system-centric approach leveraging on information, knowledge, command and control (IKC2), before finally arriving at an effect-centric model driven by robust processes that enabled it to exploit the entire spectrum of capabilities to deliver specific effects in the complex operating environment today.

This essay will first trace the historical development of artillery globally and describe how the Singapore Artillery has progressed in parallel. It will then discuss the opportunities and challenges affecting future developments, and conclude by recommending areas the Artillery should focus on.

THE EVOLUTION OF FIRES

The Early Days of Artillery

Artillery has a history that goes back many centuries. The revolution in fortification design and introduction of siege warfare and siege machines led to the beginnings of artillery. As early as 800 B.C., siege machines such as the catapult or ballista were used against the walls of Jerusalem and later employed by Alexander the Great in 322 B.C. at Tyre.[1]

Early artillery pieces were direct fire weapons. Armies had to site their field artillery carefully prior to battle because the heavy weapons were not easily maneuverable. Providing continuous fire support was impractical as the weapons were too slow to accompany armies in the field.

The invention of gunpowder, use of metallurgy to manufacture field artillery pieces, and advancements in machining permitted significant breakthroughs. These allowed for the construction of artillery that could fire at longer ranges.[2]

World War I

In WWI, artillery was predominantly used to provide fire support for defense and trench warfare. The

emphasis was on centralized command and control to influence tactical outcomes along defensive lines. In this period, there was a major breakthrough emphasizing centralized fire control to enhance the prioritization of fire support. To overcome the challenge of decreased responsiveness due to centralized control, the Americans came up with ways for headquarters to command multiple batteries and shift their fires around the battlefield. The first method involved map-spotting one or two points as targets. The other method, which did not require a map, involved adjusting one base battery on the target and using it as reference for the other batteries.[3]

WWI also saw a shift from direct fire to indirect fire for increased range and lethality. Prior to WWI, field artillery batteries generally fired directly at visible targets. By WWI, indirect fire was adopted: guns were placed a distance away from the infantry line and acquired targets by using forward observers who relayed targeting information back to the batteries.

World War II

In WWII, the decentralization of artillery command and control, aided by the introduction of portable field radios, enabled continuous fire support in offensive operations. With increased mobility, better range and more firepower, artillery took on the role of shaping the battle before maneuver forces closed in.

This was a period when the importance of logistics support in communications and transportation was elevated. The development of portable field radios provided artillery observers the flexibility and speed to follow the course of a battle and thus observed indirect fire was no longer impossible. This led to more rapid and effective shifting of fire by field artillery. As the WWII battlefield became increasingly mobile and lethal, parachute troops were introduced. Aircraft with improved carrying power and air transportable field artillery were soon developed to support airborne units.[4]

World War II also saw the development of the proximity or variable time fuse which was first used in anti-aircraft artillery. It was then adopted for field artillery and proved to be highly effective against troops and equipment in the open.[5]

Cold War

The Cold War saw the introduction of artillery systems that could deliver operational and even strategic effects. Since longer range and better mobility were two of the primary lessons of WWII, free-flight rockets and guided missiles were two weapons developed to upgrade the firepower and range of the field artillery.[6]

Using knowledge gathered from experimental rockets and test flights during the last years of the 1940s, the United States (US) Army adopted the Corporal and Redstone guided missiles, with ranges of 130km and 320km respectively, during the mid-1950s.[7] The Americans also produced free-flight rockets that lacked guidance systems, such as the Honest John with a range of 38km.[8] Although the free-flight rockets and missiles of the first generation were inaccurate, they still gave artillery units tremendous destructive power.

To be able to leverage a full suite of systems to deliver the desired effects meant that processes became more important. Protocols would be established to ensure that weapons with devastating effects were properly employed and used in concert with other systems to deliver optimal results.

Gulf War

The Gulf War demonstrated the lethality of employing fires as an integrated strike system to deliver decisive operational and strategic effects in the battlefield. The key enablers for such a system-centric model of fighting were advancements in precision technology and IKC2.

From the mid-1970s onward, technology improved artillery precision as field artillery began to widely employ computers for fire direction and adopted precision-guided munitions.[9] The Army Tactical Missile System, for example, was able hit targets at ranges far beyond any existing artillery weapon at that time.[10] The Gulf War showed that field artillery possessed an unprecedented ability to deliver tremendous amounts of accurate firepower rapidly, neutralizing and destroying Iraqi targets in quick succession.

In the 1990s, the US army began to explore and introduce new and cutting-edge artillery technology. This included digital command, control, and communication systems which facilitated battlefield coordination; fire-and-forget munitions; and new propellants to give unprecedented range.[11]

Evolution of Singapore Artillery

The Singapore Artillery first started by building its platform-centric capabilities, eventually evolving to become a critical system of the Singapore Armed Forces (SAF) strike capability. The Artillery progressively refreshed its arsenal for better range and mobility, introducing the Singapore Self Propelled Howitzer and the HIMARS to replace earlier platforms.

The Artillery also invested in IKC2 to enable better vertical and horizontal system integration. In terms of capability, it operates a digital command and control information system that enables multiple sensors and shooters to communicate seamlessly and to fight as a coherent system. Strike Observers Mission (STORM) teams that leverage on IKC2 to call for joint fires at the tactical level were also introduced. In the training realm, the Artillery runs simulator training to assess and refine the strike and targeting process. The formation also pioneered strike courses to train targeting officers for the SAF.

DRIVERS OF EVOLUTION IN CONTEMPORARY WARS

Today, how well fires can function as a system-of-systems depends on the processes that enable the desired effects to be delivered. The emphasis on processes can be attributed to three reasons. Firstly, robust decision-making and planning processes are necessary to deliver effects that are more specific than before because the modern operating environment is more cluttered and complex. Secondly, leveraging systems across services means that protocols and guidelines need to be established. Thirdly, armed forces today are expected to perform a larger spectrum of operations beyond just conventional war. These operations are less straightforward and need to be anchored on an established set of practices so that Artillery can contribute in meaningful capacities, for example as trainers or in force protection roles.

This essay has identified five key influences that have changed the way fires are employed in today's operating environment. These five factors will need to be taken into consideration when deciding on effects and designing the associated fires processes.

Technological Advancements

The development of precision attack systems and munitions enables the engagement of targets at long-range with minimal collateral damage incurred. The use of the US Global Positioning System (GPS), as well as its non-American equivalents, in the deployment of artillery has been described as "the biggest revolution since the invention of the cannon," as it provided an elegant and generally reliable solution to inaccuracy.[12]

Unmanned technology has proliferated the modern battlefield, reducing dependence on boots on the ground while extending the reach of attack and

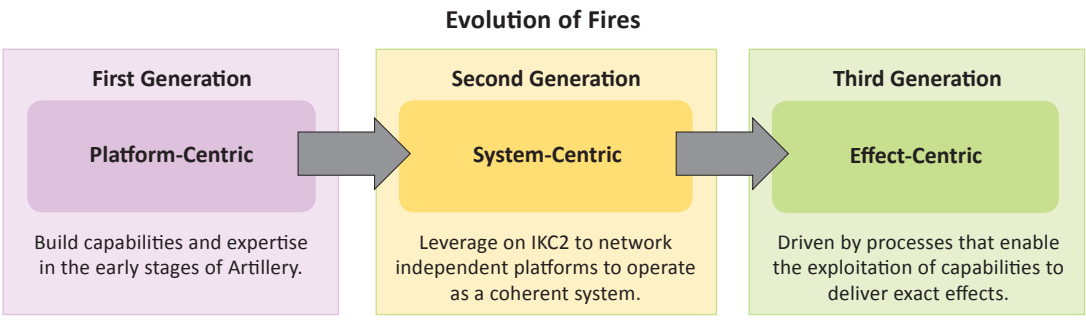

Figure 1: Evolution of Fires in Stages

intelligence systems. More than 50 nations employ remotely-controlled drones today.[13] In the concept of fires, UAVs are employed as eyes to locate and perform surveillance on targets, and to perform battle damage assessment.

Unmanned technology has proliferated the modern battlefield, reducing dependence on boots on the ground while extending the reach of attack and intelligence systems. More than 50 nations employ remotely-controlled drones today.

C4I technology has enabled more effective command and control, and has increased inter-operability across different arms and Services. The SAF is operating in a volatile, uncertain, complex and ambiguous (VUCA) environment, which demands commanders to make decisions based on information that is as complete and accurate as possible. Developments in data communications facilitate the transfer of information quickly and seamlessly. Modern C4I enables the Artillery to orchestrate joint fires from the tactical to strategic level via a sophisticated information network as "our land, maritime and air forces will need to seamlessly tap on each other's capabilities."[14]

Challenges lie ahead despite the aforementioned technological advancements. GPS and equivalents can be jammed or have their access restricted, which means that countries like Singapore that do not own satellite navigation systems are particularly vulnerable. UAVs face limitations in providing targeting data that is accurate enough for precision fires. C4I technology is expensive and time-consuming to build, and is a high-value target for jamming or hacking.

Urbanization of the Battlefield

Collateral damage is a primary concern on an urban battlefield littered with buildings and infrastructure connected by a rich network of axes. These buildings and axes offer forces a multitude of options for hardened cover and speedy transit.

Urbanization drives the evolution of fires in two ways. Firstly, there is increasing requirement for fires to be precise and its munitions effects more carefully calibrated in order to minimize collateral damage. Secondly, urbanization has elevated the importance of intelligence operations to detect targets and civilians. In the Iraq war, the 101st Airborne Division employed several ground observers and helicopters just to observe a single target in order to mitigate collateral damage.[15]

Urban targets continue to pose challenges for fires despite the advancements made in precision weaponry. GPS-guided munitions are not precise enough to strike a specified part of a multi-storey building. The presence of cover and rich subterranean networks in urban terrain impedes the detection of targets, even with the sophisticated surveillance technology available today.

Legal and Ethical Considerations

The use of asymmetric tactics, such as taking human shields and using religious buildings as cover, has led to a growing need for legal and ethical considerations when employing fires. The Law of Armed Conflict (LOAC), or *jus in bello*, "protects persons who are not or are no longer participating in the hostilities and restricts the means and methods of warfare."[16] To comply with LOAC, there is an increasing need for militaries to develop processes to avoid civilian casualties.

Increasing Influence of Information Operations

Information operations (IO) can be exploited by the enemy to erode the SAF's moral high ground and to shake morale and confidence. While fires can technically be employed against hostile forces taking cover in civilian buildings, information can be manipulated through traditional and new media to shape the perception that the use of force was excessive and unjustified. The employment of fires has therefore become increasingly integrated with IO to achieve strategic objectives.

Ability to Conduct a Full Spectrum of Operations

Conventional wars are less prevalent today. Instead, militaries are increasingly employed for missions such as peacekeeping, reconstruction and force protection. As such, the Singapore Artillery must be prepared to contribute towards the full spectrum of operations. In the recently-concluded Operations Blue Ridge (OBR), the Artillery was deployed over a period of three years in Afghanistan, during which four Weapon Locating Radar teams and six rotations of Military Institutional Trainers participated in international reconstruction efforts.

MAINTAINING THE RELEVANCE OF FIRES IN THE MODERN CONTEXT

Fires must continue evolving to stay relevant. Taking into consideration the five factors that have and will continue to influence the employment of fires, this essay recommends four areas that can be explored for future development.

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Increasing Interoperability Among Services and Tightening Integration with Intelligence

The increasingly complex battlefield demands that forces be able to see better and hit faster with more precision. Sensors and shooters across the various services, along with their associated structures and processes, must be better integrated to leverage the full capability of fires. This can be achieved by increasing training opportunities at various levels.

The SAF is already capable of integrating air and land-based fires, as demonstrated in live-fire exercises such as Exercise Forging Saber (XFS) in the US. XFS has successfully integrated fighter aircraft, attack helicopters, Unmanned Aerial Vehicles (UAVs), land-based rockets and ground observers. The Artillery's STORM teams served as "an air-land integrating agent" which "fuses the intelligence picture that it gets from its on-board sensors as well as external sensors."[17]

While fires have been evaluated at the SAF level through XFS, exercises can percolate to the tactical level, such as at the brigade, to enhance ground appreciation of how fires can contribute to operations beyond fire support. At division level exercises, it is also possible to play out the division strike processes, integrate real-time UAV imagery and train the division targeting teams in live-fire scenarios.

The SAF can explore integrating the Navy's sensors and shooters with the suite of air and land systems. This will require C4I systems that allow all three services to communicate, while the existing set of decision-making structures and processes governing the employment of joint fires will need to be refined.

Emphasizing Information Operations and LOAC in Training and Capability Development

IO and LOAC must be integrated as components of the planning process for fires to be effective on the modern battlefield. They should be treated as enablers and as part of a suite of capabilities, rather than as secondary considerations. In a cluttered battlefield where civilians and combatants may intermingle, IO will be useful in providing early warning to evacuate the former and to provide evidence for striking the latter, who could be hiding in schools or religious buildings. The fires community must be proficient in applying LOAC to make decisions under time-sensitive circumstances.

As legal and ethical considerations can potentially influence strategic objectives, it is important that commanders have access to legal advice when conducting strike operations. This needs to be incorporated into training. Commanders must also be trained to understand the implications of their decisions under LOAC and to take steps to mitigate the consequences of collateral damage.

Investing in New Capabilities

While conventional maps and UAV pictures are useful, they are flat and cannot accurately portray actual terrain. This limitation can prove significant in

the context of precision fires, especially in densely built-up areas. To solve this problem, fires can look towards 3D mapping technology. This technology will not only facilitate planning by enabling accurate visualization of the ground, but can also improve targeting precision as the observer can pinpoint the exact location of the target on the 3D map and share it with the shooter.[18]

While conventional maps and UAV pictures are useful, they are flat and cannot accurately portray actual terrain. This limitation can prove significant in the context of precision fires, especially in densely built-up areas.

With the trend towards giving soldiers on the ground more sensors and shooters to employ, it will become increasingly more complex and time-consuming to manually prioritize targets and allocate limited assets. Artificial intelligence (AI) in command and control (C2) systems, although still in its nascent stages, may be of help in this regard. Automated systems, when fed with real-time data, can be used to support headquarters in deriving optimal solutions to target prioritization and asset allocation. More advanced systems may even be able to predict and recommend where weight of fire should be concentrated if given enough information, allowing commanders to plan steps ahead.

Investments should continue to be made in precision systems and munitions. Beyond GPS-guided rockets, artillery rounds can also be made more accurate by attaching precision guidance kits to the shells.

Perform Operational Experimentation

We are already at the forefront of conceptual and operational thinking regarding fires. In order to proceed there is a need to create more opportunities to experiment, challenge current paradigms and break new ground. Some possible areas for experimentation include the use of AI in the targeting process, collaborative targeting across boundaries to leverage a wider suite of resources, and granting access to sensors and shooters at the tactical level such that strike capabilities are proliferated to the ground.

CONCLUSION

Fires has evolved tremendously over time to maintain its relevance. It initially revolved around platforms. From primitive direct fire systems that relied on mechanical energy in the olden days, artillery pieces in WWI were developed to be capable of indirect fire used for defense and trench warfare, both of which were largely static operations. Artillery was also centrally commanded. In WWII, improved communications technology allowed command and control to be decentralized. Artillery also gained mobility and range, enabling it to shape the battlefield before the maneuver forces it accompanied assaulted their objectives. Artillery's importance rose further in the Cold War and Gulf War eras as the development of precision and long-range systems enabled Artillery to deliver operational and even strategic effects. Advancements in IKC2 enabled the paradigm shift from being platform-centric to system-centric.

Today, the fires paradigm has shifted to one that is effect-centric and driven by processes to cope with the complex operating environment, contribute meaningfully to an expanded spectrum of operations, and leverage complex networked systems across the services. Five factors shape the design of effects and their associated processes:

- Technological advancements
- Urbanization of the battlefield
- Legal and ethical considerations
- Increasing influence of IO
- Ability to conduct a full spectrum of operations

The fires community should consider pursuing four areas for development to stay relevant in the modern context. They are:

- Increasing interoperability among services and tightening integration with intelligence
- Emphasizing IO and LOAC in training and capability development
- Investing in new capabilities

• Perform operational experimentation

To conclude, the role of fires has evolved from one of providing fire support at the tactical level to being a key capability employed to deliver operational and strategic effects. It has progressed from being platform-centric to system-centric, and finally to being effect-centric.

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EXCELLENCE IN PRECISION FIRES: HOW TO AVOID BEING PRECISELY INACCURATE?

By **CPT Lim En** and **CPT Daryl Tay Wei Jin**

ABSTRACT

For a long time, questions have been raised with regards to the Field Artillery's relevance and application in the modern urban environment. To avoid being precisely inaccurate, a combination of technological solutions to achieve both Precision and Accuracy must be sought to maximize the effects of Artillery fires in an urban battlefield. The accuracy of coordinates must be ensured through Target Coordinate Mensuration (TCM), achieved through use of solutions such as RAINDROP and PSS-SOF. It is only when we can engage adversaries without endangering civilians and our own friendly forces that we will be able to win both the battle and the hearts and minds of the people.

This essay has proposed existing technological solutions for the Artillery to enhance the accuracy of fires through TCM. With precise and accurate fires, we can keep our soldiers from harm and save innocent lives, allowing us to achieve a decisive victory in war.

INTRODUCTION

> *"Those skilled in war … capture enemy's cities without laying siege to them and overthrow their kingdom without lengthy operations."*
>
> *– Sun Tzu, Art of War*

The context of modern warfare has changed. With rapid urbanization, conflicts in the urban Area of Operations (AO) are becoming a reality that modern Armed Forces must prepare for. By 2025, 85% of the world's population will reside in urban areas. As Sun Tzu emphasized in the *Art of War*, one of the most significant challenges for warfare in an urban environment is the need to minimize collateral damage whilst delivering firepower to swiftly destroy and/or to neutralize targets. Questions have been raised with regards to the Field Artillery's relevance and application in the modern urban environment. The advent of precision Artillery weapons has provided an answer. Nevertheless, precise fires count for little by themselves if the targeting data is inaccurate. Existing air and land based Target Acquisition (TA) sensors today, however, provide varying degrees of accuracy in terms of the acquisition of target grids. The problem is compounded by the long latency in time required to compute, derive and transmit accurate coordinates to the shooters. The challenge, therefore, is the swift acquisition and transmission of an accurate target grid. This essay posits that as the Artillery continues develop and improve on its array of precision weapons and munitions, it is equally if not more crucial to enhance the accuracy of fires through the acquisition of better target grids. To avoid being precisely inaccurate, a combination of technological solutions to achieve both precision and accuracy must be sought to maximize the effects of Artillery fires on the urban battlefield.

This article first seeks to articulate the differences and importance of precision and accuracy in the context of Artillery fires. It will then provide an overview of the array of precision munitions and systems that can be employed by the Artillery. Last but not least, it will propose existing technological solutions for the Artillery to enhance the accuracy of fires through Target Coordinate Mensuration (TCM).

ACCURACY VERSUS PRECISION

Precision refers to the size of spread of rounds around their Mean Point of Impact (MPI), or how close they land to each other. The more compact the spread of the rounds, the higher the precision. Accuracy, on the other hand, refers to the closeness of the mean outcome of fired rounds to the desired target aim point. Whilst the Circular Error Probable (CEP) is a measure of the shooter system's precision, the Target Location Error (TLE) is related to sensor accuracy. There are two main components to accuracy: (1) how close the aim-point is to the actual target or Target Location Error (TLE) and (2) how close the rounds' MPI is to the aim-point. The first is mostly a function of the data and methods used to "fix" and orient (i.e. survey) the firing systems and to calculate their firing data. The second is a function of the accuracy and consistency of the target acquisition system and how accurate the target coordinates are, not just horizontally but also in terms of the altitude because an error in altitude results in a horizontal error in the fall of the shot. Figure 1 below illustrates the difference and the importance of both accuracy and precision.

More importantly, both accuracy and precision must be achieved to ensure that collateral damage is minimized, whilst achieving maximum destructive effects on the enemy. Section III offers some technological options that can be developed by the Artillery to achieve precision in urban warfare. These include both weapons and munitions.

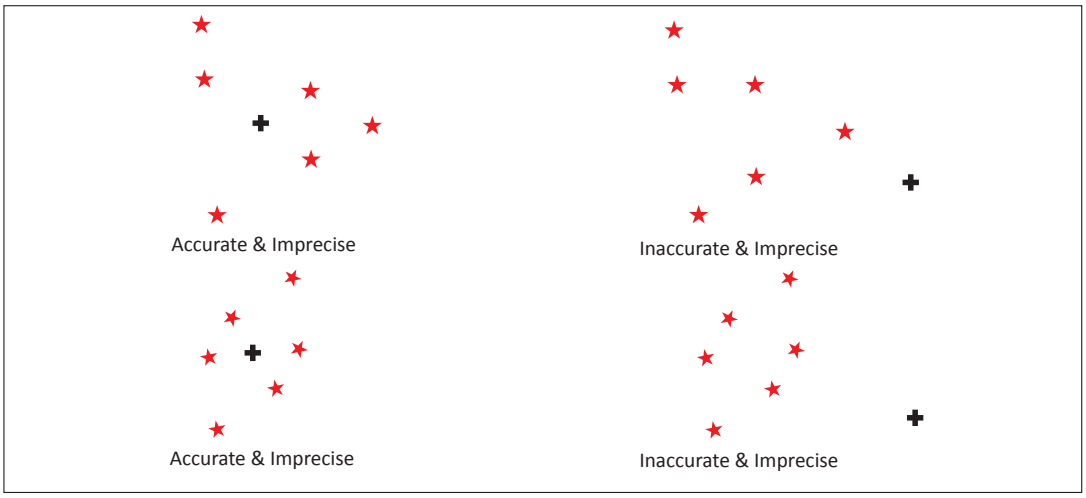

Figure 1: Accuracy and Precision

DEVELOPING PRECISION

With increased concerns over collateral damage, the need for precision fires becomes paramount. Precision munitions have different primary guidance systems and can be grouped under three main categories. Table 1 presents such grouping. GPS/INS systems are good for stationary targets or targets that rarely move, as it allows the munitions to be guided to the target area *without* any operator control for the entire flight. Man-in-the-Loop guidance systems require a person to observe the target through laser designation, while Non-Man-in-the-Loop operates using a suite of fully autonomous sensors and seekers like Infrared (IR) seekers.

GPS/INS	Man-in-the-Loop	Non-Man-in-the-Loop
GLMRS	Switchblade	BONUS-Mk-II
Excalibur	–	SMart-155

Table 1: Breakdown of Precision Munitions by Guidance System

Guided Multiple-Launch Rocket System (GMLRS)

The most successful indirect precision munitions system that has been tested in theater is no doubt the Guided Multiple-Launch Rocket System (GLMRS) rockets delivered by the High-Mobility Artillery Rocket System (HIMARS). Nicknamed the "70km sniper" for its long rage precision capability, the HIMARS was the "brigade commander's weapon of choice" during the war in Iraq.[1]

Precision refers to the size of spread of rounds around their Mean Point of Impact, or how close they land to each other. The more compact the spread of the rounds, the higher the precision. Accuracy, on the other hand, refers to the closeness of the mean outcome of fired rounds to the desired target aim point.

The HIMARS is capable of delivering a Global Positioning System (GPS) guided M31 GMLRS Unitary Rocket with an accuracy of 10m. The GLMRS has a 200-pound fragmentation warhead with an effective range of 15km to 70km. A single HIMARS Launcher can fire up to six rockets (at five-second intervals) at six different aim points within a target area, with each rocket automatically programmed to the different coordinates. However, a catch about

Illustration 1: The SAF HIMARS in Action

using the HIMARS is that its targets need to be stationary or rarely moving, such as self-propelled or towed howitzers, command posts, radars and other non-armored targets. United States (US) Commanders who have used the GMLRS in Iraq and Afghanistan have called the GMLRS Unitary a real "game changer."[2] Other than its longer range compared to conventional 155mm rounds, benefits of the GMLRS Unitary include its ability to engage targets with immense precision, its all-weather usage and its employability against targets in urban environment. The HIMARS has become the urban commander's weapon of choice for destroying enemies hidden under concrete structures or taking out IEDs, while causing minimum collateral damage to the surrounding populace or troops-in-contact (TIP).

M982 Excalibur

The Excalibur is a multinational cooperative effort between Raytheon Missile Systems of US and BAE Systems Bofors of Sweden to develop a GPS-guided projectile that can been fired from current 155mm artillery. It has a range of 50km with a CEP of around 5m.

During Operation Arrowhead Ripper in Baqubah, Iraq, the Task Force was able to use the precision of the Excalibur to achieve the desired effects on a two-story building in Baqubah, Iraq. When the Task Force fired two Excalibur rounds almost simultaneously, the munitions were so precise that the second round entered the building at the same point of impact as the first, thereby achieving the intended effects on the first floor.[3] COL Kenneth J. Lull, former commander of the 169th Fires Brigade, also shared his experience about how the Excalibur helped to take out the insurgent positions while safeguarding the Afghan populace. On one missions, 17 rounds were fired at an insurgent safe house, killing everyone in the building but causing no harm to some children playing about 30m away.

BONUS OR SMART SENSOR FUSED MUNITIONS

Across the Atlantic Ocean, the European states are also fielding another type of precision attack artillery munitions. These munitions are capable of delivering a variety of payloads to attack armored targets with an accuracy within 10 meters of the target. Two versions are already in service—the Rheinmetall Waffe Munition's SMArt 155 (DM702) jointly developed by Germany, Greece and Switzerland, and the BOFURS 155 BONUS MkII Sensor Fused Munition (SFM) produced by Sweden and France. The SMArt-155 and BONUS are 155mm projectiles fired from standard rifled 155mm artillery guns. The projectile functions as a carrier holding two sensor-fused sub-munitions, which are ejected from the shell casing mid-flight at the optimum height. Mid-flight, the Infrared (IR) guided sub-munitions deploy by parachute or winglets to hunt for potential targets within 32,000m.[4] The round is precise because of its IR capability—the infrared sensor with laser profile detector is able to analyze the shape of the potential target and separate the target from the background. The potential target must generate the correct infrared

Illustration 2: The M982 Excalibur

signal. A target is rejected if it is the wrong size, its 3D signature is wrong, or the subject is too hot (if it is already burning, for example). Once the target is positively identified, the warhead enters the attack phase. 200m above the target, the warhead arms itself and strikes downwards with an Explosively Formed Penetrator (EFP) and hit the target's roof where armor is the weakest. Another advantage of the SMArt-155 and BONUS is they are not subjected to the Convention on Cluster Munitions because the munitions are able to meet the five cumulative characteristics to prove that "they would not cause the humanitarian harm that cluster munitions do."[5] They also perform well in adverse conditions like fog, precipitation or smoke. Moreover, they are not limited to delivering lethal fires to armored targets, but also non-lethal effects that can still render non-armored targets ineffective through electromagnetic waves—instead of arming itself as a EFP, the warhead releases an electromagnetic pulse of enormous energy along a selected frequency, with the parachute acting as a directional antenna. As the pulse strikes soft-skinned vehicles, it enters via the antennas or any openings, causing all interior electronics to malfunction. Without vehicle ignition or communication, transports carrying soldiers, logistics or other essential items are effectively stopped in their tracks. At a cost of USD$40,000 per projectile, the BONUS and SMArt munitions can offer the commander a variety of different solutions depending on environmental factors within the operation area.

Switchblade

The latest precision munition in the theatre is a miniature killing drone known as the Switchblade, introduced by the US Army in their Afghanistan operations. While other munitions require a sensor to acquire the location of the target, Switchblade is both the sensor and the shooter. Similar to a fighter plane that acquires the target and delivers its onboard missiles onto the target, Switchblade is the missile. Its ability to identify the target with close range imaging and then deliver its onboard explosive payload to the target with great precision makes it suitable to engage both stationary and maneuvering targets with a high kill probability. At the same time, Switchblade's small warhead means that it yields very low collateral damage, making it the weapon of choice in urban terrain as well. In fact, its operations are similar to those of the sniper, but it allows operators to perform more complex missions at longer range, thanks to its ability to dive into the target at almost any angle and ten minutes of flight time.

ENHANCING ACCURACY

Precision guided weapons and munitions (that rely on global positioning system or GPS as part of their terminal guidance) are only as accurate as the targeting coordinates given to them. The challenge is for the TA sensors in providing an accurate grid with low TLE to direct these GPS-guided munitions to the target accurately. For the purpose of defining an acceptable TLE for the urban landscape, we will borrow the TLE concepts developed by the US Army *Joint Publication 3-09.3: Close Air Support*, the Bible of the US close air support (CAS) community, records that a "dense urban environment, with friendly ground units working cross boundaries with no easily defined forward line of own troops (FLOT) or forward edge of the battle area, will likely require a very precise and accurate target location with low TLE." This is in contrast to a conventional, linear battlefield, "where less coordinate accuracy and/or precision may be required for successful target engagement."[6] The US *JFIRE Manual* further classified TLE into six categories (CATs) which range from best (CAT 1) to worst (CAT 6).[7]

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With reference to Table 2, a CAT 1 TLE capability (6m or less, in three dimensions) is essential if GPS-guided bombs and artillery/mortar munitions are to be placed on targets with an absolute minimum risk of causing collateral damage, which is where Target

Target Location Error Categories					
CAT 1	**CAT 2**	**CAT 3**	**CAT 4**	**CAT 5**	**CAT 6**
0-6 m	7-15 m	16-30 m	31-91 m	92-305 m	>305 m
0-20 ft	21-50 ft	51-100 ft	101-300 ft	301-1000 ft	> 1001 ft

Table 2: TLE Categories

Coordinate Mensuration (TCM) comes in. However, problems arise when there is the need to fire very precisely in urban terrain (e.g. into specific rooms, or close to a civilian residence or friendly troops). The accumulated GPS error from the TA sensor and the weapon system (estimated at 15 to 30 meters) would therefore be too large. This issue is especially pertinent when the sensor data is acquired from satellite photos and UAV telemetry, given their inherent error of up to 100 meters. In the same vein, dismounted observers lack the ability to provide a precise target location. Specifically, they lack the ability to rapidly locate ground targets with better than 10 meters accuracy in all conditions, preventing engagement with precision attack indirect fire systems. Munitions may go precisely to the assigned coordinates, but those coordinates may be precisely incorrect. In these scenarios, there is a need to mensurate the target—to perform TCM before firing. TCM can be defined as the process of measuring a feature or location on the earth to determine an absolute latitude, longitude and height.[8] To obtain the most accurate geo-spatial coordinates possible, all target Desired Points of Impact (DPI) must be mensurated to reduce TLE. Correlating the expected target location to a highly refined coordinate reduces the TLE and provides a precise aim point that can be engaged with the minimal munitions necessary to achieve the desired effect. Coupled with the increased proliferation of multi-spectrum TA sources in a complex urban terrain, the need for precise TCM to support urban target engagement is crucial.

TCM Solutions

Existing commercial geospatial exploitation software products such as RAINDROP and SOCET GXP have been used by various Armed Forces to perform TCM. These products use processed digital imagery to deliver geo-location, terrain extraction and scene visualization. In general, the products deliver three elements: accurate geodetically controlled stereo imagery, compressed graphics and image support data.[9] Comparisons of points "dropped" on stereo images of the target area referenced against the embedded metadata provides the enhanced Target Location Accuracy (TLA) required by GPS-guided Precise Munitions. For instance, for deliberate targeting, SOCET GXP is the only tool authorized by the UK Targeting Directive to produce geospatial co-ordinates for PGMs employed by the UK Armed Forces.[10]

The accuracy of coordinates must be ensured through TCM, and this can be achieved through the use of various technological solutions such as the RAINDROP, SOCET GXP and PSS-SOF. It is only when we can engage adversaries without endangering civilians and our own friendly forces that we will be able to win both the battle and the hearts and mind of the people.

More recently, the Precision Strike Suite-Special Operation Forces (PSS-SOF) has been developed and operationalized by the US Armed Forces during Operation Iraqi Freedom. The PSS-SOF is a new joint service data communications network that allows Forward Observers to develop an extremely precise three-dimensional (3D) grid coordinate for a specific target. PSS-SOF does not give mensurated targeting, but its near-mensurated targeting allows targeting to achieve 10 meters accuracy. A soldier using PSS-SOF employs GPS to find his own location. Then he takes a laser and paints a target, so he can see the target on grid coordinates and also on a map. PSS-SOF then draws on 3D imagery from the National

Illustration 3: A USAF Joint Terminal Attack Controller equipped with a Modular Tactical System (MTS), which includes a Tactical Mission Computer (TMC) that runs PSS-SOF mensuration software.

Geospatial-Intelligence Agency so the soldier can see whether the location of the target he's about to shoot is correct. If the location is wrong, that soldier can drag and drop an icon on his computer screen to the correct location so that precise munitions can be fired at the target. The entire process can be completed under one minute by single operator. This has greatly sped up the process of TCM and the resultant sensor-shooter loop.

These TCM solutions have greatly reduced the TLE and improved accuracy in Artillery Fires. For instance, since 2007, miss distances of 5 meters or less have been recorded against ad-hoc targets by Canadian, UK and US forces on operations in Afghanistan and Iraq, using either Excalibur or GMLRS. This was made possible with the use of US-supplied TCM software such as the PSS-SOF or BAE Systems SOCET-GXP/Northrop Grumman RainStorm headquarters mensuration systems. These have been closely held by the US Government and have generally only been accessible to the "five-eyes" nations (Australia, Canada, New Zealand, UK and US). With these TCM solutions, Artillery spotters or Forward Observers will now be able to conduct TCM during operations to acquire more accurate grid coordinates for the various shooters.

CONCLUSION

The present array of precision weapons and munitions offer the commander options and flexibility to engage his target with the best outcomes in constrained terrain. Based on the type, size and location of the target, the commander can now decide whether he wants to employ a 500-pound warhead with Close Air Support (CAS), 200-pound warhead using the GLMRS or 50-pound warhead using the Excalibur. The Switchblade, BONUS-Mk-II and SMArt munitions provide the commander with the capability to destroy armored targets effectively. With this menu of precision strike capabilities to choose from, commanders can be assured of fires capabilities to effectively shape its battlefield and execute changing missions across the spectrum of conflict.

Nonetheless, as demonstrated in this essay, precision munitions are not enough to defeat the enemy. The accuracy of coordinates must be ensured through TCM, and this can be achieved through the use of various technological solutions such as the RAINDROP, SOCET GXP and PSS-SOF. It is only when we can engage adversaries without endangering civilians and our own friendly forces that we will be able to win both the battle and the hearts and mind of the people. With precise and accurate fires, we can keep our soldiers from harm and save innocent lives, allowing us to achieve a decisive victory in war.

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PIERCING THROUGH THE FOG OF WAR WITH C4ISR-STRIKE

By **MAJ Kwek Kian Leong**, **CPT Chan Yen Shun**, **CPT Edwin Cai** and **CPT Lam Li Wen**

ABSTRACT

This essay discusses how C4ISR-Strike can be enhanced to deliver fires that are timely, tailored, accurate and precise. This is crucial as the modern battlefield is draped with a thicker "fog" that is characterized by the increased difficulty of locating targets and conveying target coordinates to the shooters. The manifestations of C4ISR-Strike will thus meet the operational challenges of tomorrow's battlefield.

INTRODUCTION

The Clauswitzian "Fog of War" describes the cumulative effects of chances, uncertainties and friction in war that impede a commander's ability to make informed and sound decisions. Although the Artillery has traditionally been the force of choice to neutralize the enemy before the close-in battle, today's battlefield has rendered traditional artillery modes of delivery inadequate. With battles increasingly taking place in complex urban terrain, the modern battlefield is draped with a thicker "fog" that is characterized by the increased difficulty of locating targets and conveying target coordinates to the shooters. This requires the Artillery to relook at their modus operandi in order to pierce through the "fog" to deliver fires that can achieve the desired military outcome and meet the demands of a world that has become increasingly intolerant of collateral damage.

As defined in the US *Joint Publication 1-02*, Strike is "an attack to damage or destroy an objective or a capability." While this definition seems straightforward, Strike involves a more complex process known as targeting. Targeting is "the process of selecting and prioritizing targets and matching the appropriate response to them, considering operational requirements and capabilities."[1] The process is complex as it is a "combination of intelligence functions, planning battle command, weaponeering, operational execution and combat assessment." In order to better manage and mitigate the complexities, the Artillery will need to embrace C4ISR-Strike, a concept that expounds the complementary relationship between Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) and Strike to deliver Fires that are timely, tailored, accurate and precise.

C4ISR-Strike does not simply mean fitting C4ISR technologies into current Strike modus operandi. It represents a conceptual shift in the way the Artillery thinks about Strike operations. It will open up new frontiers, bring about new possibilities on what Strike operations can achieve, and significantly enhance the ability to bring Fires to bear on the enemy. Fires will be highly scalable and tailored according to the desire effects. Enhanced situational awareness will provide a comparative advantage over adversaries by striking them faster than they can. Communications technology facilitates a seamless flow of information from the sensors to the decision-makers to the shooters, truncates and automates processes, and thereby reduces mission processing time.

As it would be too ambitious a task to cover C4ISR-Strike in its entirety, this essay will instead focus on how Strike operations may be enhanced by

the improved connectivity brought about by C4ISR technologies. This essay will begin by sharing on the impetus and key tenets of incorporating C4ISR into Strike operations. Following which it will discuss how processes may be framed and streamlined to exploit the capability and potential of C4ISR-Strike. Finally, it will share on the tactical physical manifestation of C4ISR-Strike in the form of STrike ObserveR Mission (STORM) teams.

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IMPETUS OF C4ISR-STRIKE

Definitions of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)[2]

Command and Control (C2) — The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission.

Computing and Communications — Two pervasive enabling technologies that support C2 and intelligence, surveillance, and reconnaissance. Computers and communications process and transport information.

Intelligence (I) — The product resulting from the collection, processing, integration, analysis, evaluation, and interpretation of available information concerning foreign countries or areas. Information and knowledge about an adversary obtained through observation, investigation, analysis, or understanding.

Surveillance (S) — The systematic observation of aerospace, surface or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means.

Reconnaissance (R) — A mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area.

The prowess of network-centric warfare was aptly demonstrated at contemporary wars. In Operations Iraqi Freedom (OIF), forces were no longer split cleanly along Service lines but were integrated as one highly networked fighting entity. Interoperability and Command and Control (C2) issues were overcome with advanced information and communications technology, allowing Strike Planners to utilize the entire arsenal of sensors and shooters to prosecute strike missions efficiently and effectively.

As part of the Third Generation SAF Transformation, the SAF has identified precision weapons, unmanned systems and Integrated Knowledge-based Command and Control (IKC2) technologies as three key areas of growth.[3] IKC2 reflects the need for the SAF to be network-enabled and organized around knowledge for effective C2. Concept of operations and organizational structures will also need to evolve around IKC2 in order to reap maximum benefits from this networking.[4] As the SAF expands her arsenal of sensors, shooters and munitions with advanced systems such as the HERON 1 UAV, the HIMARS, the Apache Attack Helicopters and the JDAM, there is a need to leverage on IKC2 to network these equipment in order to realize their collective full potential. This has given rise to the concept of C4ISR-Strike.

TENETS OF C4ISR IN C4ISR-STRIKE

The US Department of Defense articulates the tenets of Network-Centric Warfare (NCW) as "a robustly networked force improves information sharing and collaboration, which enhances the quality of information and shared situational awareness. This enables further collaboration and self-synchronization and improves sustainability and speed of command, which ultimately result in dramatically increased mission effectiveness."[5] Drawing reference from the tenets of NCW, this essay has identified four key tenets of C4ISR in C4ISR-Strike that summarize how the cognitive domain interacts with the physical domain to deliver Fires that are timely, tailored, accurate and precise.

Firstly, information superiority aids in better and faster decision-making. At the cognitive level, information superiority offers comparative advantage over the enemy in terms of information relevance, accuracy and timeliness. It bestows superior shared situational awareness (SA) through information obtained from the intelligence grid which aids commanders in making faster and better decisions.[6]

Secondly, self-synchronization of actions, decisions and intent at all levels results in more expedient execution of Strike. Commanders on the ground can be given more autonomy in carrying out Strike missions when they are able to synchronize their actions, decisions and intent with that of the Higher HQ. Self-synchronization is made possible as C4ISR provides tools for commanders to share information, plan strike missions on the go, and appreciate how their actions relate to the overall battle through a Common Operations Picture (COP). However, synchronization of efforts can only be achieved after satisfying four supporting pre-requisites. Firstly, there must be a set of doctrines that provide guidance; secondly, soldiers must understand and be trained according to the established doctrines; thirdly, there must be communications between the various elements in the battlefield; and lastly, commander's intent must be clear and conveyed to all relevant parties. Self-synchronization plays an important role in the third tenet – Speed of Command.

Speed of Command represents the process of converting information in the cognitive domain to actions in the physical domain and translating superior information position into competitive

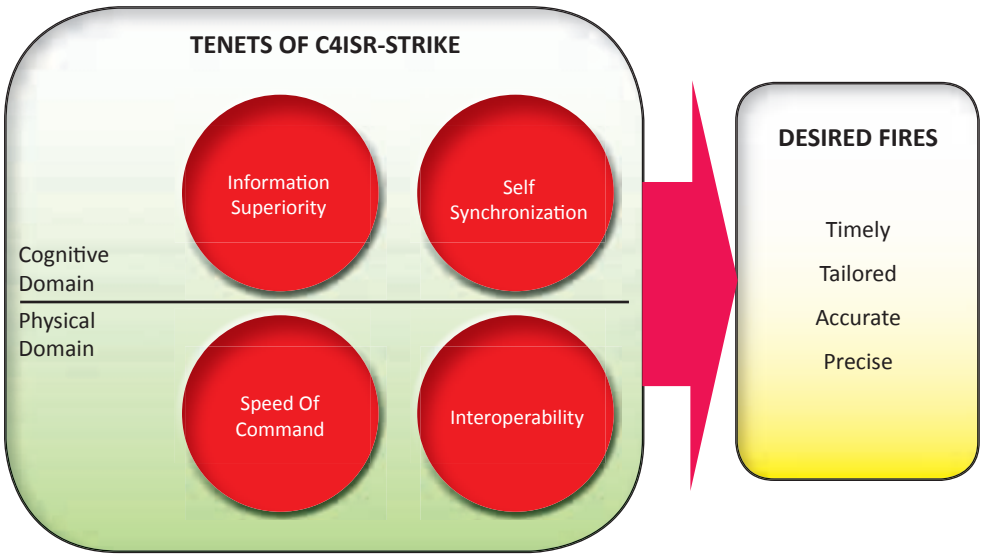

Figure 1: Tenets of C4ISR in C4ISR-Strike

advantage.[7] This requires a seamless flow of information from the sensors to the decision makers to the shooters, an efficient and effective decision-making mechanism, as well as a some form of automation where man-in-the-loop processes are truncated or skipped with the aid of information technology and established doctrines. It offers the ability to control the tempo of Strike missions, be it fast or slow, according to tactical or operational requirements.

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Fourthly, information technology facilitates interoperability of sensors and shooters at the systems and operational levels. The concept of interoperability focuses on maximizing combat capabilities. In the SAF's formative years, capabilities were largely developed along Service lines with little thought spent on integration amongst the Services. This gave rise to differing doctrines, operating languages, culture and modes of operations that were Service-specific. For example, the Air Force utilizes Latitude and Longitude for its grid coordinate system while the Army uses MGRS. Information technology bridges these differences, thereby allowing Strike Planners to leverage on an expanded suite of assets that come from the various Services to quickly deliver Fires that yield the desired effects. Furthermore, combat operations of the future will most likely be conducted in an alliance or coalition environment and will inevitably be joint as well as combined, and thus underscore the importance of interoperability with our allies and coalition partners.[8]

FRAMING AND STREAMLINING PROCESSES FOR C4ISR-STRIKE

As mentioned previously, Strike involves Targeting, a complex process that is a "combination of intelligence functions, planning battle command, weaponeering, operational execution and combat assessment." Targeting methodologies can be used to mitigate the complexities by compartmentalizing the Strike process into logical steps to facilitate Strike missions. Some of the targeting methodologies used by the U.S. military include D3A (Detect, Decide, Deliver, Assess), F2T2EA (Find, Fix, Track, Target, Engage, Assess) and F3EAD (Find, Fix, Finish, Exploit, Analyse, Disseminate). This section will discuss how the U.S. military uses F2T2EA to frame and streamline their Strike processes.

FM 6-30 defines D3A (Decide, Detect, Deliver, Assess) as a targeting methodology used to "facilitate the attack of the right target with the right asset at the right time."[9] Although D3A might work well for deliberate targets (e.g. scheduled and on-call targets), it might not be sufficient for processing dynamic targets (e.g. targets of opportunity with limited exposure time). Engaging dynamic targets will require a more responsive targeting methodology. F2T2EA is one such targeting methodology that allows commanders to find and engage dynamic, time-sensitive and high-payoff targets within a compressed time frame. It is a modification of the D3A methodology, defining in more specific terms the requirements for engaging dynamic targets and allowing for many of these steps to be executed simultaneously, thereby reducing mission processing time. The six steps of F2T2EA are explained as follows:

The first step of the dynamic targeting process is "Find." This step involves using intelligence, surveillance and reconnaissance (ISR) assets to identify potential targets on the battlefield, in accordance with commander's guidance.

The second step "Fix" begins upon identification of potential targets. ISR assets are focused on these targets to further determine their identity and precise location. They are used to determine the targets' identity in terms of whether they are stationary or mobile, whether they are all-weather and all-terrain capable, and also to determine the degree of accuracy required by the engaging weapon system based on the data gathered. Targets are classified and confirmed at this step.

The third step is "Track" whereby sensors continue to observe the confirmed targets until an engagement decision has been made and executed.

This is especially important for mobile targets as continued surveillance is required until they are neutralized.

The fourth step, "Target," takes in a host of considerations to determine whether the confirmed target should be engage and how it should be engaged. For instance, this involves deciding what the desired effects on the target should be, matching available shooter and sensor assets against the desired effect while mitigating collateral damage and fratricide risks to the lowest.

The fifth step is "Engage." Engagement orders are given to the shooter to engage the target. This is especially challenging for mobile targets as traditional ballistic munitions are unlikely to be effective against mobile targets. Munitions will need to be guided to the target at the terminal phase. Terminal guidance of munitions is made possible by C4ISR, which provides the critical link between C2 elements, sensors and shooters to ensure a successful hit on the target.

The last step is "Assess" whereby the allocated sensor gives an examination of the results of the engagement to determine if the desired effects have been achieved. A re-engagement may be recommended if the desired effects are not achieved.

The six steps of F2T2EA show how C4ISR is inherent and essential in the targeting process. Decision points are built into the targeting process for commanders to exercise command and control (C2). For example, commander's guidance is required during the "Find" step to decide what targets need to be detected, what ISR assets to be deployed, which targets need to be continuously tracked and which targets are to be engaged. With the aid of computers, some of these decisions may be skipped or made automatically if a pre-determined set of criteria is satisfied. The preferred shooters and munitions can also be recommended based on the desired effects, proximity and range of shooters, and whether rules and laws are infringed upon. Computers and communications technology also facilitate C2 of ISR assets during the "Find," "Fix," "Track" and "Assess" stages. Information and data are processed into useful forms to help Strike Planners sense-make and determine the most appropriate course of action.

STORM – THE TACTICAL PHYSICAL MANIFESTATION OF C4ISR-STRIKE

CASE STUDY: ANGLICO, the Fire Support and Liaison Units of the USMC

The Air Naval Gunfire Liaison Companies (ANGLICO) are the fire support and liaison units of the United States Marine Corp (USMC).[10] They were formed in 1949 with the mission of supporting Navy-Marine Corp, Navy-Army operations and were widely known for their ability to control Close Air Support (CAS).[11] Besides that, they are equally well-trained in ground-based fires that include cannon artillery, rocket artillery, precision guided munitions such as GMLRS, naval gunfire support, and fire support coordination. ANGLICO played instrumental roles in supporting the US Army in the Korean War, the Vietnam War and more recently Operation DESERT STORM in Iraq and Operation ENDURING FREEDOM in Afghanistan.[12] For Urban Terrain Battle, the ANGLICO teams also proved to be key assets for the Marines by providing critical CAS, naval gunfire and Marine artillery control when precision matters most.

All the ANGLICO units require the Marines to be proficient in a wide variety of specialised military skills to suit the unit they are supporting. Besides attending Tactical Air Control Party (TACP) School to obtain certification as Joint Terminal Attack Controller (JTAC), ANGLICO Marines are also required to attend stringent training in Basic Airborne, Ranger, Pathfinder and Helicopter Rope Suspension Training in order to support Special Operation missions. The high level of trainings and proficiency make ANGLICO units among the toughest and one of the most highly regarded tactical liaison unit in the USMC.

Ever since Operation TELIC (the British military campaign in Iraq) in 2003, the British Army had recognized that their Forward Observation Officers (FOO) parties from the field artillery regiments attached to ground troops were

unable to conduct Joint fires effectively.[13] CAS was not tapped adequately to support the operations which resulted in unnecessary combat casualties. The capacity to conduct air-space management and the management of associated battle space were also relatively weak compared to their US counterparts. In comparison, the ANGLICO won admiration from the allies by demonstrating lethal air-land integration of fires which dominated the battlefield. In response to this operational gap, the British Army started to develop their own Fire Support Team (FST), which consists of a Commander, a Forward Air Controller (FAC), an Artillery Controller, an Attack Helicopter controller, a Mortar Fire Controller (MFC), drivers and signallers.[14] This task force is much more comprehensive and effective in supporting air-land integrated missions.

The SAF has been mooting the idea of a Strike force that is able to coordinate precision air-land fires with enhanced network capabilities in support of manoeuvre operations. STrike ObserveR Mission (STORM) was thus introduced as a key feature in the Third Generation SAF Strike Operations.[15] STORM teams enhance tactical fire support in three areas.

Firstly, STORM teams are capable of executing tactical urban fires. It will bring forth responsive and urban-capable precise fires to isolate the urban Area of Operations (AO), as well as to destroy High Payoff Targets (HPTs) before the close-in battle. They will be plugged into the intelligence grid and supported by a reliable communications network.

Secondly, the Sensor-STORM-Shooter process loop is shorter and more responsive. In the new operating environment, enemy fighting platforms are expected to be modernized with mobility and protection. STORM teams will

INTEGRATED STRIKE MISSIONS

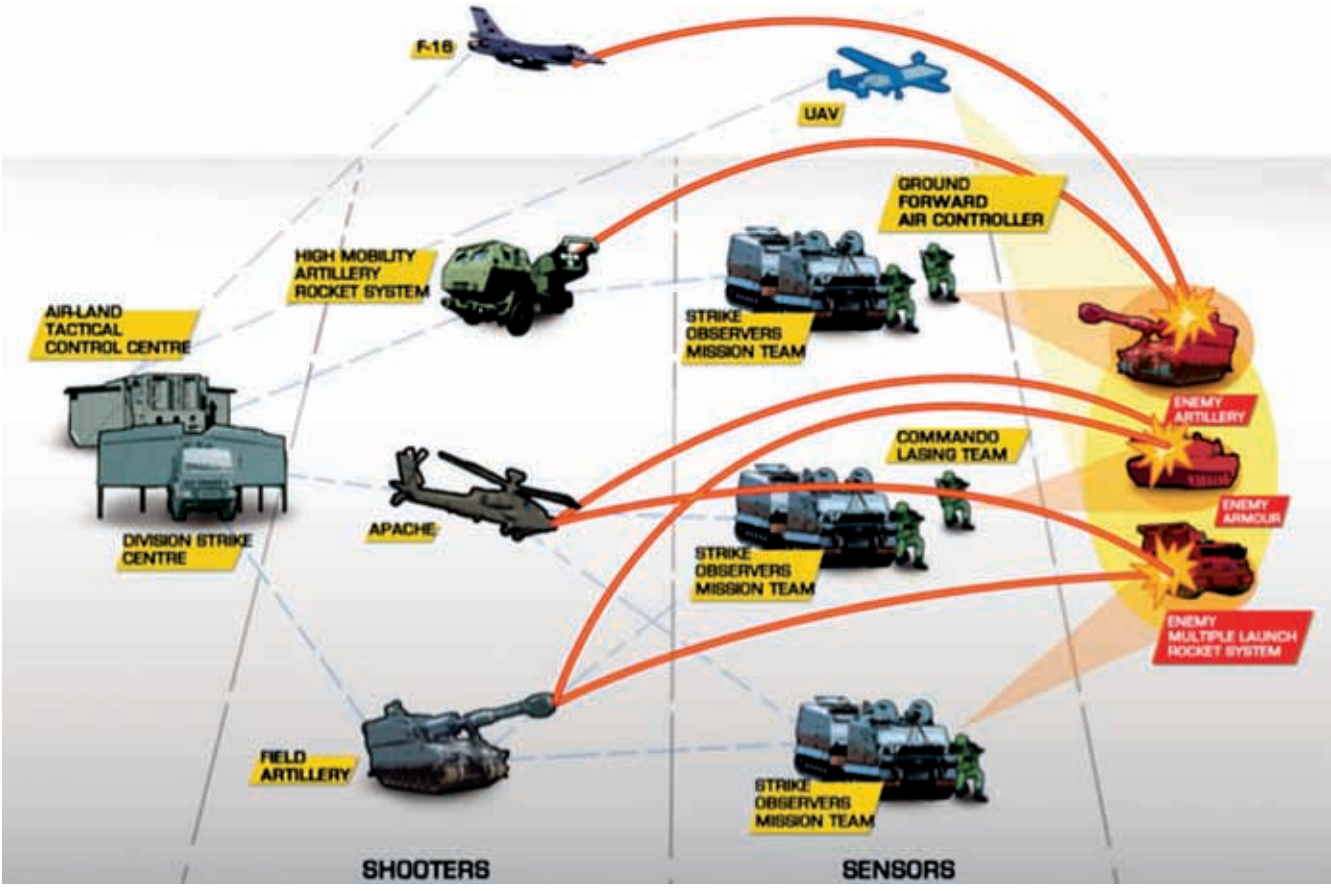

Figure 2: Illustration of Integrated Strike Missions orchestrated by STORM.[16]

be the key combat force to execute last-mile targeting to destroy moving targets and targets of opportunity while mitigating collateral damage and fratricide risks to the lowest. They will execute a closely coordinated air-land fires mission combining near real-time intelligence from assets such as UAV and Army Combat Man System (ACMS) with Common Operations Pictures (COP). With computers, decision-points can be automatically skipped and processes can be truncated when the situation satisfies a pre-determined set of criteria.

The SAF has been mooting the idea of a Strike force that is able to coordinate precision air-land fires with enhanced network capabilities in support of manoeuvre operations. STrike ObserveR Mission (STORM) was thus introduced as a key feature in the 3rd Generation SAF Strike Operations.

Thirdly, STORM teams support air-land firepower integration. Land fires alone may not be able to achieve the desired effects that the commanders require in tomorrow's operating environment. With better C4ISR network, STORM teams will synergize and concentrate air-land fires to where it is most crucial to achieve the desired effects.

With enhanced C4ISR and network capabilities, STORM teams have the ability to rapidly direct a wide range of land- and air-based sensors and shooters to engage targets. Sensors include Unmanned Aerial Vehicles (UAVs) and Human Intelligence (HUMINT). Shooters include the F-15SG/ F-16 Fighter Aircraft, Apache Attack Helicopters, High Mobility Artillery Rockets System (HIMARS) and the Singapore Self-Propelled Howitzers (SSPH). This is a significant capability enhancement, as previously, artillery fires and air strikes had to be called separately by the Forward Observers (FOs) and the Ground Forward Air Controllers (GFACs). The shorter sensor-shooter loop thus enables STORM teams to deliver highly accurate and timely air-land Fires. This was demonstrated at Exercise WALLABY 12 held at Shoalwater Bay Training Area (SWBTA) in Queensland Australia where STORM teams showed how C4ISR was integrated with Strike by utilizing surveillance information from the sensors (scouts/UAV) to locate enemy target quickly and activate air and land shooters to strike at the target at the right time and on the right spot.[17]

CONCLUSION

C4ISR-Strike has provided new conditions that call for a re-designing of concept of operations to fully exploit the power of networking to prosecute Strike missions. In addition, improved situational awareness due to C4ISR has given rise to flatter command structure, which results in faster prosecution of Strike missions. At the tactical level, C4ISR-Strike can be proliferated to small or tactical units such as STORM teams, which can be deployed to the edge of the battlefield and granted greater autonomy to coordinate Fires for enhanced last-mile targeting. With C4ISR-Strike, Strike operations will be able to better meet the operational challenges of tomorrow's battlefield by delivering timely, tailored, accurate and precise Fires.

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FUTURE ARTILLERY FIRES

By **CPT David Kwek** and **CPT Lim Wee Yeow**

ABSTRACT

This essay seeks to envisage the form of future artillery fires that will offer a wide spectrum of options that are at the disposal of the commander, to choose from massed, destructive cannon fires, to pin-point precise missile strikes, to calibrated lethality targeting. Therefore, these developments aim to solidify the status of artillery as "King Of The Battlefield" in tomorrow's fight.

INTRODUCTION

Over the years, developments in artillery fires have redefined its role on the modern battlefield. From the Napoleonic horse-towed howitzers to modern long range precision missile launchers, this essay will study how fighting concepts, artillery platforms and munitions have evolved and envisage the form of future artillery fires.

FUTURE CONCEPTS

Massed Fires to Precision Fires

The two things that the artilleryman is most concerned with, in the delivery of fires, are Accuracy and Precision,[1] and thus he strives to achieve these two conditions by meeting the "Five Requirements for Accurate Predicted Fire."[2] Even with his best efforts, inherent imprecision remains, which is the immutable characteristic of conventional ballistic artillery fires. This imprecision, known in Artillery parlance as "dispersion," spans from meters to hundreds of meters depending on the range to the target. As such, the concept of "massed fires" is normally associated with artillery, whereby multiple guns and batteries are required to deliver volleys of fires on a target to achieve the desired effect. With the traditional concept of "massed fires," the use of Artillery fires was akin to using a mop to paint a picture. It would get the job done, but it would be messy and splash paint everywhere.

However, we cannot afford to use a mop to paint pictures. The increase in the political and operational impact of fires has brought about great emphasis on the need for precision fires. In modern conflicts, the camera has been an instrument of war, capturing incriminating photos of civilian casualties that sway global support and discredit the opposing force. Photographs travel faster than bullets now. As such, the need to limit collateral damage is a necessity and one way to do so is to employ precision fires.

Today's artillery rounds are no longer simply "dumb" munitions that are subject totally to ballistic forces, but contain sophisticated electronics that can steer rounds onto the target. Precise "smart" munitions also require fewer explosives to affect the target than imprecise dumb munitions. This "one-hit-one-kill" ability reduces collateral damage and increases operational tempo, both desirable outcomes in modern wars. Precision fires have transformed Artillery from a mop into a fine-tip marker, allowing us to draw clear and sharp lines.

"1 or 0" Effects to Spectrum of Effects

Artillery munitions were first developed with the primary purpose of causing lethal damage to personnel. Shells containing explosive filling were

Figure 1: Footage of harm to civilian lives in war can travel quickly.[3]

used, as early as in the 14th century, fitted with a time fuse to ignite the explosives, fragmenting the shell casing into deadly shards. Incendiary filling was also used to great effect against early ships and structures made of wood, causing terrible damage to personnel who suffered the spillover effects. Technological advancements introduced more sophisticated munitions. Fuses could function based on time countdown, radar proximity, point detonation and time delay after impact, and payloads became deadlier, with improvements in high explosives, white phosphorous and cargo rounds, making artillery fires a formidable force against personnel, armored vehicles and reinforced structures. While these capabilities have earned artillery the moniker "King of the Battlefield," artillery tends to be a "1 or 0" instrument, being only able to inflict massive destruction on the battlefield, with the alternative of not being employed at all. It can be used to great effect in a conventional war, but is not very useful in a peacekeeping mission. Today's modern battlefield is also not as sanitized as before, with hostile legitimate targets being harder to distinguish from non-combatants. This requires a calibrated approach, which traditional artillery is incapable of.

Future artillery fires will be able to overcome this dilemma with the inclusion of calibrated precise fires and non-lethal fires. Calibrated precise fires will utilize munitions that may have a lower destructive yield but are just as effective, or more so, due to increased precision, which also minimizes collateral damage. Non-lethal fires can include munitions that disrupt electronics, disperse incapacitating agents or produce effects that destroy the enemy's will to fight. The inclusion of calibrated precise fires and non-lethal fires expands the artillery's capabilities and allows it to support a greater spectrum of operations in complex operating environments, instead of just hot wars in conventional terrain.

Supporting Role to Starring Role

The World War II-era fighting model is maneuver-centric, hinging on the principles of maneuver to target the enemy's Center of Gravity and dislocate their command and control through shock and action.[4] Artillery fires were normally used to support the maneuver elements as they assaulted the objectives, as preparatory fires to destroy, neutralize or suppress the enemy. This supporting role of artillery is invaluable to the success of the maneuver mission, assisting with offensive fires, such as neutralization fires to "soften" the defender's position and block fires to isolate the defender, or defensive fires such as fire barriers and final protective fires.

However, future artillery fires have the potential to take centrestage in tomorrow's fight. Tasks normally conducted by maneuver can be performed with future artillery fires as well. For example, in offensive operations, the success of the block mission is usually a key factor, to prevent enemy reserves from arriving and tilting the relative combat power. A block force would usually comprise a sizeable maneuver force reinforced with crew-served weapons, tank-hunting teams and pioneers providing counter-mobility support. This task may now be performed solely with artillery fires, with a single observer calling for area denial artillery munitions to fix an enemy convoy in place, precision anti-tank missiles to destroy armored vehicles, and airburst high explosive projectiles to neutralize remaining personnel. Artillery fires can also be used in defensive maneuver operations, such as delay battles in the security area. A well-placed observer will be able to call upon the entire arsenal of artillery to establish walls of devastating fires composed of high explosives and obscuration smokescreens, effectively halting the enemy advance.

Artillery is also able to contribute immensely in non-conventional operations as well. It can be utilized for information operations, delivering information leaflets using artillery cargo rounds to far-flung places. Riot control agents can also be dispersed over a large area quickly to quell uprisings peacefully,[5] without the risk of deploying troops.

Precision fires coupled with artillery's superior range allow for decisive victories, without line of sight to the enemy. If there are targets in depth, commanders need not deploy heliborne or coastal hook maneuver forces, which are highly vulnerable to enemy attack, but can use long-range artillery fires to take out the targets precisely in a fraction of the time required, with far less risk involved. Potentially, this may allow the winning of the depth battle before the forward battle even begins.

FUTURE PLATFORMS

From Towed to Self-Propelled

Artillery platforms have evolved over history, from being horsedrawn to vehicles-towed and, finally, being self-propelled. Mobility is an important principle for artillery, which must be able to move quickly to deliver timely fires in support of maneuver and also to enhance its own survivability, being able to employ a "shoot-and-scoot" concept to avoid enemy counterfire. Today's self-propelled platforms are either on wheels or tracks and can deploy in virtually all forms of terrain, both conventional and urban, without requiring embedded trail spades. This will be necessary as tomorrow's fight is more likely to be in cities rather than jungles and open plains due to increased urbanization.

Reduced Manpower with Automation

The downside to heavy firepower offered by artillery is the immense effort required to operate such heavy and bulky equipment. The standard 120mm mortar bombs weigh more than 10kg while 155mm projectiles weigh more than 40kg—about two-thirds of the average Singaporean adult's weight. As such, if you were big and tall, you were more likely to be chosen to serve in artillery than say, armor. To overcome this, modern artillery platforms are increasingly automated, with machines doing all the heavy lifting, minimizing the fatigue of the crew and enhancing sustainability. Automation also reduces the manpower requirements for artillery. For example, the towed FH-88 howitzer requires 8 men to operate, while the recently purchased M142 High Mobility Artillery Rocket System (HIMARS) only requires three men to operate, despite having bulkier ammunition and greater capabilities.

Figure 2: The M142 High Mobility Artillery Rocket System (HIMARS) only requires three men to operate.[6]

Improved Force Protection

Another area of possible development for platforms is better force protection. The most likely threats against artillery are air attacks, raids by special forces and counter-fire. To defend against air attacks, artillery weapons should be equipped with anti-aircraft capabilities or be co-located with air defenses. They should also be equipped with active protection systems with soft-kill or hard-kill capabilities to guard against anti-tank weapons. Counter-fire is usually avoided by employing "shoot-and-scoot" tactics. However, in the event that this is not possible, Counter-Rocket, Artillery, Missile (C-RAM) systems can be deployed to form a protective bubble around the assets.

FUTURE MUNITIONS

Impractical Long Range Cannon Artillery

The greatest strength of artillery is its range and it is natural that armies should seek to maximize this advantage over their opponents. However, maximizing the range of cannon artillery is not practical, due to the wear and tear caused by the additional propellant in the barrel. A popular example is the Paris Gun, German long-range siege weapon used to bombard Paris in World War I which boasted the longest range for cannon artillery. It could fire 216mm shells weighing 106kg up to a range of 130km. However, due to the immense amount of propellant required in firing, each shot

wore down the barrel width significantly, requiring the use of increasingly larger projectiles to maintain a gas-tight seal when firing. It was also slow and had poor accuracy over long ranges. The Paris Guns became a liability in prolonged operations and were better in intimidating the enemy than making any materiel contribution to operational success.

Achieving Precision and Long Range with Rockets and Missiles

Instead of packing the propellant in the breech, it can be placed in the projectile instead. This enables in-flight propulsion, turning the projectiles into rockets. Sophisticated electronics can also be incorporated into rockets, allowing them to steer themselves onto the target. The HIMARS is capable of firing GPS-guided rockets. These precise rockets have earned the HIMARS the nickname "Sniper."[7] Boeing is also developing a "gliding missile," the Ground Launched-Small Diameter Bomb (GL-SDB), that has wings to allow it to glide to its target after the motor propels it to a suitable height and has a ramge pof 150km.[8] There is also the MGM-140 Army Tactical Missile System (ATACMS) which has a range of 300km, used in great effect in Operation Iraqi Freedom where more than 450 were fired to strike critical high-value targets in the depth. The ability to engage the enemy accurately at great distances provides for flexibility in the employment of fires, with a firing unit being able to support both the fight at the Forward Edge of Battle Area (FEBA) line and the depth battle, without having to displace. The entire security area effectively becomes the killing ground.

Precise Cannon Artillery

Although cannon artillery lacks range compared to rocket artillery, it is able to achieve high or equal precision as guided rockets. There are smart rounds that are terminally guided by laser designators, such as the M712 Copperhead, and Global Positioning System (GPS) guided rounds as well, such as the M982 Excalibur round. Dumb but cheap cannon rounds, such as the standard 155mm HE M107 projectile, can be equipped with inexpensive Course Correction Fuses (CCF) which provide guidance to the desired target. Examples include the GPS-enabled XM1156 Precision Guidance Kit and the SPACIDO fuse which communicates to a ground station that tracks the round with a Doppler radar.[10] For these guided rounds, precision error is no longer a function of range — effective range has been increased to match its maximum range.

Calibrated Lethality

It is widely accepted that artillery fires are destructive—120mm bombs and 155mm rounds have effective killing radii of around 25m and 37m respectively. However, modern battlefields often include urban objectives with non-combatants in the Area of Operations, which rules out the option of wanton destruction with artillery fires. The destructive effects of artillery fires must hence be scalable, to be able to deal with targets in conventional terrain, where the collateral damage is less of an issue, to urban settings where the

Figure 3: The MGM-140 Army Tactical Missile System (ATACMS) has a range of 300km.[9]

rules of engagement are stricter. Ideally, lethality should not only be calibrated but also selective. Munitions that are able to detect, assess and select targets before delivering destructive effects are immensely useful. Such munitions would require "eyes" to observe, a "brain" to orient and decide, and "legs" to act accordingly. An example would be Tube-launched, Optically-tracked, Wire-guided (TOW) missiles which are equipped with electro-optical cameras that send the video feed back to the operator, who then assesses the target before engaging with the missile. The ideal artillery munition would be one that is able to detect and conduct positive identification of the enemy whilst in flight and decide whether to engage the target or not, with scalable destruction effects.

Non-Lethal Effects

Artillery is also able to deliver non-lethal effects in addition to destruction. Illumination munitions are used by artillery to illuminate the battlefield, and the illumination traditionally takes the form of visible light, a double-edged sword which can work in favor of the enemy and potentially give away the location of friendly inserted elements. Recent developments have used the near infrared spectrum instead, providing our soldiers a field of view advantage with night vision devices, enhancing the tempo and mission success of night operations. Some examples include the M1066 155mm IR illlum Cartridge, and XM983 120mm IR illum.

Artillery is also capable of obscuration effects, such as using White Phosphorous rounds to produce smokescreens to obscure the enemy's visual sight. Taking this one step further is the inclusion of Electronic Warfare (EW) capabilities to produce obscuration effects against electronic sight. The level of technology and networking required of the modern fighting force makes it heavily dependent on electronics for operational success. Command, Control, Communications and Computers (C4) systems, Intelligence, Surveillance, and Reconnaissance (ISR) sensors and platforms, and air and land based strikers all operate on electronics in one way or another and are dependent on communications for integration. The Russian 3RB30 and American 9M519 are examples of Artillery Delivered Expendable Jammer (AD/EXJAM) munitions that can be fired into enemy territory to jam radios and electronics. A more lethal electronic warfare munition is the Counter-electronics High Power Microwave Advanced Missile Project (CHAMP)—a joint development originated from the US to develop an air-launched directed-energy weapon capable of incapacitating or damaging electronic systems.

Outside of the battlefield, the role of artillery could be expanded to Operations Other Than War. Stand-off delivery of riot control agents can reduce the danger and number of boots on the ground in riot control situations—M630 mortar and M629 105mm

Figure 4: The XM982 Excalibur is equipped with GPS and fins which allow it to glide accurately onto the target.[11]

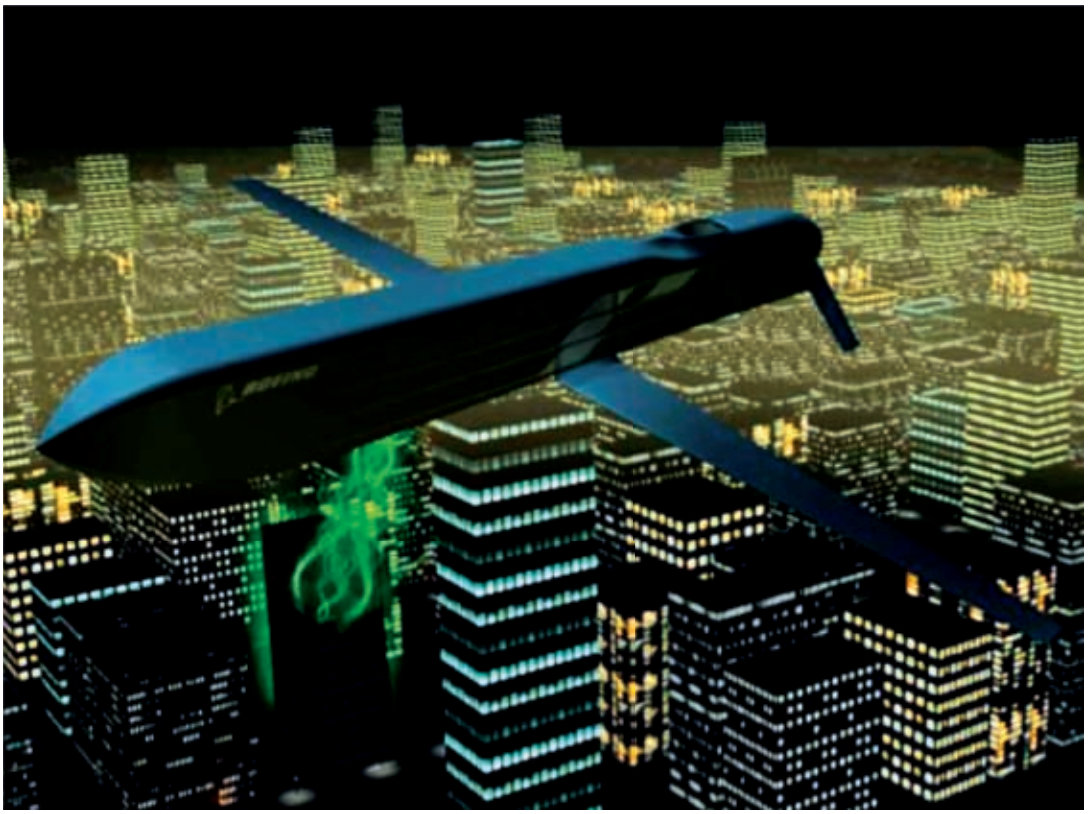

Figure 5: Boeing's Counter-Electronics High-Powered Microwave Missile (CHAMP) destroys electronic targets, not people.[12]

munitions are examples.[13] They eject pyrotechnic mix canisters on impact or at proximity, releasing riot control agents over a duration of about 60 seconds. Riot control task forces can fire these munitions over riots before sending forces in—similar to the concept of supporting fires during maneuver, effectively breaking up riots with a state of confusion, degradation and poor visibility. Besides riot control, they can be used on the battlefield for direct support of maneuver elements on known or suspected targets to harass or confuse enemies and inhibit their ability to interfere with the primary battle. These munitions are potential replacements for white phosphorous incendiary munitions.

Psychological Operations

In wars fought in urban environments, winning the war often involves winning the psychological war for the hearts and minds of the local populace. During World War II, the Germans designed a special shell called "Weiss-Rot Geschoss" for spreading leaflets by artillery.[14] The British used 25-pounder grenades and Americans used 105mm and 155mm for similar purposes. In more recent developments, a patent was filled in 11 October 2001 for the creation of an artillery launched flyer assembly.[15] The flyer assembly is designed to be fitted into an artillery munition and can be jettisoned based on user preset conditions.

FUTURE SENSORS

Integrating Land and Air Fires

The most lethal, accurate and precise artillery weapon is useless without good intelligence. While the shooters are the "muscles" of artillery, the sensors are the "eyes" to identify targets, direct fire and assess the damage. Forward Observers (FO) are trained artillerymen who fulfill this role. They are attached to the maneuver unit, to serve as the link between the maneuver commander and the firing unit. However, fires can also take the form

of air fires, such as munitions delivered by fixed wing or rotary aircraft. In this case, we have Ground Forward Air Controllers (GFAC) to direct these fires accurately on target.

In the future, we will be fielding Strike Observer Mission (STORM) teams, which are mobile teams that integrate the capabilities of the FO and GFAC.[16] They specialize in the search and destruction of targets, able to call upon the whole spectrum of land and air fires to accomplish their mission.

Eyes in the Sky

In order to acquire targets and direct fires accurately onto them, observers are required to be deployed near the FEBA or even behind enemy lines, in order to maintain line of sight. Nevertheless to say, this is a risky job. A way to overcome this is to employ Unmanned Aerial Vehicles (UAVs) to act as the "eyes in the sky" for the firing units. Modern UAVs can be equipped with a variety of sensors, from conventional Electro-Optical/Infrared (EO/IR) that can see in day and night, to Synthetic Aperture Radars (SAR) which can see through clouds, foliage, and even sand or soil to detect targets underground.[18] There are fixed-wing and rotary-wing variants, with the former having the advantage of long operational range at high speeds, and the latter able to hover and maintain persistence surveillance, and perform Vertical Takeoff and Landing (VTOL). Looking ahead, aerial drones and autonomous UAV swarms are likely to revolutionize the field of Intelligence Surveillance, Reconnaissance (ISR) and can minimizing risk by replacing the human observer on the ground.

IDEAL ARTILLERY SYSTEM

As a thought experiment, let us postulate the form of the ideal artillery system. There are two possible options.

The first option emphasizes mobility and speed. There would be many firing units, platoon-sized or less, equipped with self-propelled platforms that are quick and mobile to employ shoot-and-scoot techniques. They do not require a long range as they are able to maneuver close to the FEBA line to fire before returning to concealed positions. Command and control should be decentralized, with each firing unit able to perform computation tasks and mission processing. They should be

Figure 7: The US Navy's MQ-8 Fire Scout UAV can be equipped with the Tactical Synthetic Aperture Radar (TSAR), allowing it to see through dense foliage, clouds, and even sand or soil.[17]

able to fire a spectrum of munitions with varying levels of precision as per mission requirements. However, the logistics support required would be challenging given the mobility of the platforms, hence it would be more efficient to utilize more precise and lethal munitions, so less ammunition would be required. This option takes the form of platoons of wheeled or tracked cannon artillery firing area effect munitions with Course Correction Fuses or Excalibur-type guided precision rounds. Fire control will be provided by commando teams or STORM teams located near the maneuver, to locate targets and direct the fires accurately onto them.

The second option emphasizes sustenance and range. Conversely, there would be a few firing units that are emplaced in hardened and static positions, able to withstand aerial or artillery bombardment. These firing units will be protected by static air defense systems, such as Ground Based Air Defenses (GBAD), to neutralize air threats and Counter-Rocket, Artillery, Mortar (C-RAM) systems to defend against incoming fires. They would have the ability to fire a spectrum of munitions with extreme range at a high rate of fire to support the entire Area of Operations without need for displacement. Since they are probably located within the main support area, sustenance of various ammunition types will be possible. This option models after Multiple Launch Rocket Systems (MLRS) that are able to fire long-range missiles, such as the M30/M31 rockets or the MGM-140 ATACMS, with the support of area defense assets such as the Tactical High Energy Laser (THEL). In this case, UAVs will be used as sensors to locate the targets in depth, control the fires, and conduct Battle Damage Assessment (BDA).

CONCLUSION

Future artillery fires is not just a new concept of precision fires. It is also not about missile artillery platforms or even non-lethal munitions. Instead, it covers the wide spectrum of options that are at the disposal of the commander, to choose from massed, destructive cannon fires, to pinpoint precise missile strikes, to calibrated lethality targeting. These advancements will allow artillery to take on a greater role in battle, being able to operate just as well or even better than maneuver elements in fulfilling traditionally maneuver tasks. Artillery is and will continue to dominate tomorrow's fight as the King of the Battlefield.

1. Accuracy refers to the degree of closeness of the fired rounds to the aimed point while Precision is the closeness of the fired rounds to one another.
2. They are: 1) Accurate Target Location and Size, 2) Accurate Firing Unit Location, 3) Accurate Weapon and Ammuni-tion Information, 4) Accurate Meteorology Information and 5) Accurate Computational Procedures.
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ETHICS IN FIRES

By **CPT Mikail Kalimuddin** and **CPT Hong Wenxian**

ABSTRACT

As the role of the Artillery has broadened to encompass more than traditional Fire Support, so has its ethical responsibility. Each new technological advance places us farther from our foes—if we see the enemy not as humans but pixels on a screen, we risk becoming psychologically disconnected from the horrors of war. Each Gunner must not only internalize his ethical and professional duties, but must have the moral courage to take the right stand when necessary.

INTRODUCTION

For the Singapore Armed Forces (SAF) to succeed in its operations, it must conduct itself in a manner that is morally above-board. Any reprehensible conduct by our troops, when reported to the press, could lead to an erosion of public support for the war, as well as a loss of cohesion within the units concerned. Translated to the tactical level, the SAF's servicemen and women must therefore be able to effectively handle the ethical dilemmas they will confront in the course of their duties. This requires that our capacity for ethical reasoning is well exercised by deliberately identifying and grappling with possible dilemmas in today's operating context.

Traditional Artillery was spared much of this burden. Fire Support (FS) is predominantly concerned with the delivery of lethal effects rather than decisions as to its ethical appropriateness—a task often left to manoeuvre commanders. That is not to say that the Artillery has been ethically unencumbered. For example, a Field Artillery (FA) element that comes under attack may, in deciding whether to persist with an ongoing fire mission, choose between its own survival and the survival of its supported unit. However, as the role of the Artillery has broadened to encompass more than traditional FS, so has its ethical responsibility. Through its targeting operations, the Artillery of today simultaneously functions in support of manoeuvre and parallel to it. By doing so, it has been forced to consider issues such as proportionality, necessity and responsibility,[1] much like the front line elements it has traditionally supported.

As the scale and complexity of the Artillery's targeting operations continue to grow, so too will the role of ethics in fires. Furthermore, as technology makes targeting a reality at lower echelons, a growing proportion of Artillery personnel will find themselves confronted with ethical decision-making. With this future in mind, it is the intention of this essay to posit the operating context for tomorrow's Artillery and the attendant ethical challenges.

TRENDS

We have identified four trends that are likely to contribute new dimensions to the environment in which the Artillery operates and consequently shape the types of ethical dilemmas that it will be faced with.

Automation. Military systems will be increasingly able to execute complicated tasks independently. Complicated tasks follow a relatively straightforward logic, but involve many steps. For example, today's Artillery platforms are equipped with automatic

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survey and fire control systems, taking the technical aspects of operation out of the hands of the operator. The physical deployment of platforms can now be as simple as pushing a button or series of buttons. Coupled with unmanned vehicle technology, it is conceivable that in time to come FA elements may even be controlled remotely, keeping personnel out of harm's way. Similarly, the role of a Forward Observer could be carried out remotely through the use of unmanned ground or air sensors equipped with the necessary targeting capabilities. Unmanned sensors will be able to stay in the field indefinitely and be free of the effects of fatigue, stress and emotion when carrying out tasks. For the Artillery, automation will progressively negate the need for personnel to be co-located with the systems they operate.

Artificial Intelligence. Military systems will be increasingly able to execute complex tasks independently. Complex tasks involve what we perceive as judgement. This requires the system to make sense of a large quantity of inter-related real-time and reference data in order to arrive at a conclusion that would normally be made by a human. This represents a key difference from automation in that the need for a human anywhere in the mission cycle, from finding a target to conducting post-engagement assessment, is obviated entirely. In this sense, the way the term "unmanned" is currently used makes it a misnomer, a more accurate term being "remotely-manned." The infusion of artificial intelligence will allow for truly "unmanned" or "optionally-manned" platforms. Lethal systems, like South Korea's autonomous SuperAegis2, that are able to identify personnel as targets and automatically engage them already exist.[2] In time, an intelligent system may be able to identify a column of enemy vehicles, determine the most effective method of engagement, engage the target and conduct the damage assessment without

human intervention. Even ammunition could be made intelligent by allowing it to independently select its effect settings in the terminal phase of flight based on input from sensors on the projectile. The software that allows for any such intelligence will most likely include an "ethics package," but this is still some way from battlefield use.[3] For today's militaries, the decision to engage a target—the point at which a decision cannot be unmade—still resides with the unmanned vehicle operator and not the vehicle itself.[4] However, as the pace of battle and complexity rise, allowing an intelligent system to make such a decision will likely become an increasingly attractive option.

Cyber Warfare. The growing role of Information Communications Technology (ICT) in networked warfare will put military elements at increasing risk of cyber attack. Unmanned Aerial Vehicle (UAV) feeds, target data, friendly force information and terrain intelligence will be prone to spoofing, intrusion and jamming in the same manner that analogue radio communications are today. As our reliance on data received over digital networks grows, so does the risk to information security. Instead of combating physical forces, a hostile force could instead opt to combat our information networks surreptitiously, causing confusion and fratricide. Given the Artillery's reliance on accurate data, the possibility of compromised data cannot be taken lightly.

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Terrain. The terrain the SAF will operate in will continue to increase in complexity. With motorization of forces, long-range weapon systems and "Command Control Communications Computers Intelligence Surveillance and Reconnaissance" (C4ISR) systems with vastly increased reach, the impact of physical geography is lessened. However, the human geography of our operating environment will continue to be a growing challenge. Urbanization, the emergence of non-traditional threats, social media and the evolution of civil-military interactions in the

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battlefield are some examples of the increasing impact of human geography for the military.[5] In the context of fires, human geography translates to complications for assessment of collateral damage, target discrimination and unintended civil effects.

SCENARIOS

In this section of the essay, two scenarios are presented based on the trends discussed above. Each scenario demonstrates how a combination of trends could place Artillery operators in an ethical dilemma that could occur in the future.

Scenario 1: Decision Responsibility

LTA Lim is an Unmanned Forward Observer (U-FO) team commander supporting a manoeuvre Brigade (Bde). His Bde has been tasked to capture a largely deserted town to cut off one of the enemy's main routes of advance. LTA Lim is responsible for deploying four U-FO systems at the periphery of the town to provide close Fire Support for manoeuvre elements in their assault on the town. Owing to the highly mobile nature of small-unit enemy forces moving throughout the town, LTA Lim has been given orders to allow the U-FO to engage targets without human intervention in order to cut down the mission-cycle time. The U-FOs are able to reference the Bde's fire support coordinating measures, blue-force tracking system, and conduct surveillance on movement of combatants and non-combatants while deployed. This helps to ensure that collateral damage and fratricide is minimized.

While deploying one of the U-FOs, LTA Lim notices that small groups of men dressed as civilians are constantly shuttling between buildings. They appear to be unarmed, but there seems to be no reasonable explanation for civilians to be moving about in this manner. He begins to suspect that the enemy is employing small groups of combatants dressed as civilians to move about the town in order to create a false civilian presence. Based on the engagement protocols of the U-FOs, this will heavily restrict target engagement in order to conform to collateral damage requirements. Given the circumstances, Fire Support from the U-FOs is likely to be limited and ineffective, increasing the risk to friendly manoeuvre forces.

LTA Lim has a few options: (1) He could relax the civilian-detection protocols of the U-FOs and risk engaging actual civilians. (2) He could transfer engagement control to himself,

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allowing him to do the target discrimination but in doing so also increase mission cycle time considerably. (3) He could do nothing, and simply stick with his orders as-is.

Scenario 2: C4ISR Attack

CPT Ng is a Fire Direction Officer of an FA element supporting the Division in targeting operations against High Payoff Targets. As the Division has begun its capture of the first set of objectives, CPT Ng expects that enemy reserves are likely to launch a counter-offensive at any moment.

An UAV providing a direct-feed to the FA element picks up a company-sized cluster of armoured vehicles in the vicinity of a small town. CPT Ng's attack guidance requires him to respond immediately with destructive fires in order to eliminate this possible reserve element. Overlaying the target grid provided by the UAV with his blue-force tracking system, CPT Ng confirms that there are no friendly elements in the target area.

Upon closer inspection of the blue-force data, CPT Ng notices that the friendly element positions deviate significantly from the scheme of manoeuvre that he was briefed on before the start of the mission. The UAV video feed is also showing a number of anomalies, including a fluctuating UAV flight altitude and higher-than-usual degradation in the quality of the video image. CPT Ng is concerned that his C4ISR systems may be compromised, but the indications are marginal at best.

CPT Ng has a few options: (1) He could escalate the target data to the Division for confirmation. In the time it would take to do so there is a high possibility that the armoured elements will have moved, and given the high density of foliage in the target area he is likely to lose the target. (2) He could ignore the discrepancies and follow his attack guidance but risk engaging friendly forces and give away the position of his firing units.

The Asymmetric Cyber Threat

IMPLICATIONS FOR THE ARTILLERY

As the above scenarios illustrate, the ethical dilemmas in the future paradigm of strike operations will be more challenging to navigate. Our capacities to make ethical decisions must therefore evolve at the individual, tactical and strategic levels.

Individual Ethics. Future warfare will demand greater ethical consciousness from our Gunners, as lower echelons play a larger role in strike operations. Yet, as each new technology places us farther from our foes and we see the enemy not as humans but pixels on a screen, we risk becoming psychologically disconnected from the horrors of war. The high tempo of operations will also result in orders being given based on incomplete information. More than ever, each Gunner must be well-prepared to act ethically.

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Ultimately, when faced with an order that conflicts between professional duty and ethics, it is one's individual responsibility to decide whether or not to obey. To manage these dilemmas, one may make his decisions based on an *Ethical Triangle* (See Figure 1).[6] The *Ethical Triangle* has three dimensions. First, one must consider his *obligations* as a military professional. While mission success is paramount, it is also professionally wrong to carry out orders that are against existing laws, codes and conventions. Second, one must consider the *consequences* by weighing any anticipated military advantage against the necessity of lethal force and the risk of harming non-combatants. Third, one should ensure that the orders do not go against his *personal virtues, values and integrity*.

Using Scenario 2 as an example, CPT Ng is faced with a conflict due to potentially faulty target data. Based on his obligations, CPT Ng has a professional duty to carry out the orders of Higher Headquarters. As the enemy is clearly distinguishable, he is cleared to engage them within legal boundaries, even if the enemy did not pose immediate threat. Based on the consequences, there is a risk of fratricide or civilian casualties by executing the mission. The loss of lives may not be worth the military advantage

Figure 1: The Ethical Triangle[7]

to be gained from pre-emptively engagingly the enemy. Lastly, from the virtues perspective, it is up to CPT Ng's personal conviction and his ability to live with his actions thereafter. These three factors will guide his eventual actions.

In such morally ambiguous scenarios, our Gunners can rely on tools such as the Ethical Triangle, but need the space to do so. The SAF must empower them to decide for themselves, given that the rules-based military hierarchy could be perceived to favour compliance over independent thinking. Discipline and individual empowerment are not mutually exclusive. Where there are established codes of conduct, rules of engagement and standard operating procedures, our Gunners should behave in accordance with the prescribed rules. But there will be grey areas in operational situations, where the rules are silent, not sufficiently clear, or even contradictory. The organization should entrust our Gunners to exercise their individual discretion.

The ability to make carefully considered ethical decisions does not happen by chance, and must be systematically developed. Therefore, the SAF must equip our Gunners with the necessary moral competencies. Based on the Ethical Triangle, we should develop our Gunners' understanding of their obligations as military professionals, their ability to weigh the consequences of their decisions, and their awareness of personal values. The intent is for our Gunners to internalize these moral competencies to the extent that they consistently govern their conduct under even adverse combat conditions.

HQ SA

Exercising Individual Ethics

To this end, the SAF should continue to integrate military ethics into our training programmes. Research on the Swiss Armed Forces has shown that short-term courses are effective in developing competencies for moral decision-making.[8] Likewise, the SAF may offer courses on military ethics—teaching our Gunners about existing laws and conventions will raise awareness for their obligations in war; giving practical skills to deal with dilemmas will help them better consider the consequences. In the context of the Artillery, relevant case studies, such as past atrocities arising from Fire Support, contemporary examples of drone strikes, or hypothetical future scenarios, could be woven in. This would begin a conversation on the ethical realities facing us as Gunners, allowing us to reflect and build upon our moral foundations. Furthermore, as moral competencies tend to decline over time,[9] it is important to embed ethics within our everyday training, beyond one-off programmes. For example, we could introduce ethically challenging scenarios into field exercises and after-action reviews. By providing practical examples for discussion, commanders help their men to bridge the gap between abstract moral standards and their operational actions.

During operations, however, there is an inevitable tendency for individuals to revert to ethically inappropriate behaviour due to the stresses of combat. The SAF could conduct anonymous mental health questionnaires on our troops to better support them.[10] If ethical violations are discovered, the SAF is obligated to punish those who have committed war crimes. But more importantly, we should investigate and address the underlying factors, such as combat stress, anger over unit casualties, or a poor command culture that failed to emphasize ethics or stifled open reporting.

Ethical Tactics. At the tactical level, the Artillery must incorporate ethical considerations into the entire targeting process to guard against the unintended consequences of our fires. In planning targets to strike, sensitive sites such as schools, mosques and cultural sites should be avoided. In populated areas, it is especially important to obtain accurate and precise target location data in order to ensure the safety of non-combatants. There should also be sound weapon-to-target matching to ensure that the targets are engaged in a proportional manner and minimize collateral damage arising from target overkill. As an extension, we could consult military lawyers and civilian groups to check for blind spots. For example, the Pentagon had adopted this process in creating a Joint Target List for the 2003 Iraqi invasion.[11]

During the execution of targeting operations, there is also a need to emphasize process discipline so as to prevent ethical mistakes. Gunners must constantly check against the approved target lists and other fire support coordination measures that designate the allowable limits of fires. While our systems may automate these checklists, there should be human intervention at critical junctures. If a target contravened these boundaries but is assessed to be militarily necessary, we should seek approval for the strike mission from suitable authorities to ensure accountability. During the 2003 Iraqi invasion, such missions had to be approved by senior United States (US) civilian leaders.[12]

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Commanders should also be equipped with sufficient battlefield situational awareness to help them assess the larger impact of their decisions. While individual strike targets might be proportional and ethical, they could have unintended effects when seen in totality. This will be enabled by C4ISR improvements, but we should not downplay other sources of information. Scenario 2, for example, showed how CPT Ng's appreciation of the overall battle picture had enabled him to potentially avert an unfortunate outcome.

After a target has been engaged, the SAF could consider sending "civilian casualty response teams" to manage the follow-on issues.[13] The teams should

have a wide range of expertise, such as medical personnel, information officers, munitions disposal specialists, military lawyers and intelligence experts. Such response teams can evaluate the impact of military operations on the civilian population, in a way that typical Battle Damage Assessments (BDA) might not. Their findings may be used to refine targeting tactics, techniques and procedures, and assist in criminal investigations if mistakes occur.

Strategic Perspective. Amidst advancements in warfare, some of the fundamental age-old rules of war remain valid. Singapore must continue to adhere to internationally accepted legal frameworks in order to retain her legitimacy in a post-conflict scenario. In a prolonged conflict, popular support will also be critical in winning the hearts and minds of non-combatants. With the media being so pervasive in today's military operations, any signs of unethical conduct by the SAF could easily be blown out of proportion. To achieve a strategic victory, all aspects of the SAF's military campaign must be above board.

The Artillery should integrate our strike operations with the rest of the SAF to ensure that ethical imperatives have been met in the overall battle strategy. An example of such integration can be seen in the US military's offensive against Al Qaeda in Tal Afar in 2005, where great effort had been made to minimize civilian casualties.[14] Prior to the offensive, civilians in affected areas were informed to evacuate, while those in other parts of the city were directed to remain in their homes. Air strikes and Artillery struck insurgent defensive positions using Precision Guided Munitions, and with persistent eyes on targets. Strikes were also timed to minimize the risk to non-combatants. This laid the way for the main ground offensive by US and Iraqi forces. As a result of synchronization at the strategic level, civilian casualties were greatly reduced.

Open Questions. While the trends of future warfare necessitate a return to fundamental ethical principles, they also open up several unexpected challenges. For one, removing humans from the battlefield could desensitise the public to the human deaths on the frontline, as society could perceive wars to be fought among machines rather than people. We see signs of this today—although the US drone war in Pakistan has caused hundreds of civilian casualties, domestic support largely remains strong. Without the same risk to human lives, the political cost of military action could be lowered. In a future where unmanned strike systems fight head-to-head, states may have to exercise restraint to avoid escalating to war.

The increasingly sophisticated targeting systems will also be able to process a far more complex set of engagement protocols and at much higher speeds than what humans are capable of. We expect more automated and intelligent systems without a man in the loop. But what if the system goes wrong? Who is to blame for any unintended consequences? Should the commander who oversaw the targeting mission be held responsible? Or the engineers who created the system and may have overlooked the defects? Does this also make us less sensitized, because we can blame the machine instead? Referring to Scenario 1, LTA Lim faces such a situation, if he decided to override the automated protocols of the U-FOs but inadvertently engaged actual civilians. On one hand, LTA Lim, as the commander, arguably failed to take feasible precautions. On the other, to punish him could, from a legal perspective, be placing more trust in the judgement of the computer than in the human actually at the frontline. Indeed, today's military laws may not be sufficiently nuanced to assign legal responsibility for unintended errors inflicted by automated systems.[15]

While the future operating context brings about a new set of ethical challenges, it is interesting to note the potential for unmanned technologies to make the conduct of war more ethical amidst a more complex battlefield. In 2007, the US Army commissioned a study of how a lethal autonomous system could be build with an ethical reasoning system, and concluded that that robots may not

just be "perfectly ethical in the battlefield," but more ethical than "human soldiers are capable of."[16] Unmanned autonomous systems, such as the U-FOs in Scenario 1, do not suffer from combat fatigue or emotional influences that could cloud judgment. Smart weapons that can distinguish between different targets, may also give the ability to only shoot at hostile combatants. Tapping on these opportunities will be equally important as addressing the attendant ethical challenges in future warfare.

CONCLUSION

Military ethics is not an excuse for the SAF to go soft—it is of strategic importance, as popular support and international legitimacy will be crucial to Singapore's survival post-conflict. The importance of ethics in fires will grow, given that the burden of ethical decisions will increasingly fall on those who conduct strike operations, especially at the lower echelons. Our capacities to grapple with these issues must thus evolve. Each Gunner must not only internalize his ethical and professional duties, but must have the moral courage to make the right stand. The Artillery should empower and equip them to do so. In the course of targeting operations, the Artillery must also put in place processes to guard against ethical mistakes as well as enforce system discipline. Collectively, the various arms of the SAF, including the Artillery, should be well-integrated to run a military campaign that achieves the strategic ethical imperatives.

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7. Ibid.

8. Stefan Seiler, Andreas Fischer and Sibylle A. Voegtli, "Developing Moral Decision-Making Competence: A Quasi-Experimental Intervention Study in the Swiss Armed Forces," *Ethics & Behavior*, no. 6 (2011), 452. The authors studied the effectiveness of a one week training programme in moral decision making on participants from the Swiss Armed Forces. Findings suggest that such interventions raised moral self-awareness and improved the participants' ability to adopt a structured decision-making process, and had positive long-term effects.

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11. Ibid., 16

12. Ibid., 16

13. Ibid., 46

14. Ibid., 30-32

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ETHICS IN FIRES

By **CPT Mikail Kalimuddin** and **CPT Hong Wenxian**

ABSTRACT

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Scenario 2: C4ISR Attack

CPT Ng is a Fire Direction Officer of an FA element supporting the Division in targeting operations against High Payoff Targets. As the Division has begun its capture of the first set of objectives, CPT Ng expects that enemy reserves are likely to launch a counter-offensive at any moment.

An UAV providing a direct-feed to the FA element picks up a company-sized cluster of armoured vehicles in the vicinity of a small town. CPT Ng's attack guidance requires him to respond immediately with destructive fires in order to eliminate this possible reserve element. Overlaying the target grid provided by the UAV with his blue-force tracking system, CPT Ng confirms that there are no friendly elements in the target area.

Upon closer inspection of the blue-force data, CPT Ng notices that the friendly element positions deviate significantly from the scheme of manoeuvre that he was briefed on before the start of the mission. The UAV video feed is also showing a number of anomalies, including a fluctuating UAV flight altitude and higher-than-usual degradation in the quality of the video image. CPT Ng is concerned that his C4ISR systems may be compromised, but the indications are marginal at best.

CPT Ng has a few options: (1) He could escalate the target data to the Division for confirmation. In the time it would take to do so there is a high possibility that the armoured elements will have moved, and given the high density of foliage in the target area he is likely to lose the target. (2) He could ignore the discrepancies and follow his attack guidance but risk engaging friendly forces and give away the position of his firing units.

The Asymmetric Cyber Threat

IMPLICATIONS FOR THE ARTILLERY

As the above scenarios illustrate, the ethical dilemmas in the future paradigm of strike operations will be more challenging to navigate. Our capacities to make ethical decisions must therefore evolve at the individual, tactical and strategic levels.

Individual Ethics. Future warfare will demand greater ethical consciousness from our Gunners, as lower echelons play a larger role in strike operations. Yet, as each new technology places us farther from our foes and we see the enemy not as humans but pixels on a screen, we risk becoming psychologically disconnected from the horrors of war. The high tempo of operations will also result in orders being given based on incomplete information. More than ever, each Gunner must be well-prepared to act ethically.

Yet, as each new technology places us farther from our foes and we see the enemy not as humans but pixels on a screen, we risk becoming psychologically disconnected from the horrors of war.

Ultimately, when faced with an order that conflicts between professional duty and ethics, it is one's individual responsibility to decide whether or not to obey. To manage these dilemmas, one may make his decisions based on an *Ethical Triangle* (See Figure 1).[6] The *Ethical Triangle* has three dimensions. First, one must consider his *obligations* as a military professional. While mission success is paramount, it is also professionally wrong to carry out orders that are against existing laws, codes and conventions. Second, one must consider the *consequences* by weighing any anticipated military advantage against the necessity of lethal force and the risk of harming non-combatants. Third, one should ensure that the orders do not go against his *personal virtues, values and integrity*.

Using Scenario 2 as an example, CPT Ng is faced with a conflict due to potentially faulty target data. Based on his obligations, CPT Ng has a professional duty to carry out the orders of Higher Headquarters. As the enemy is clearly distinguishable, he is cleared to engage them within legal boundaries, even if the enemy did not pose immediate threat. Based on the consequences, there is a risk of fratricide or civilian casualties by executing the mission. The loss of lives may not be worth the military advantage

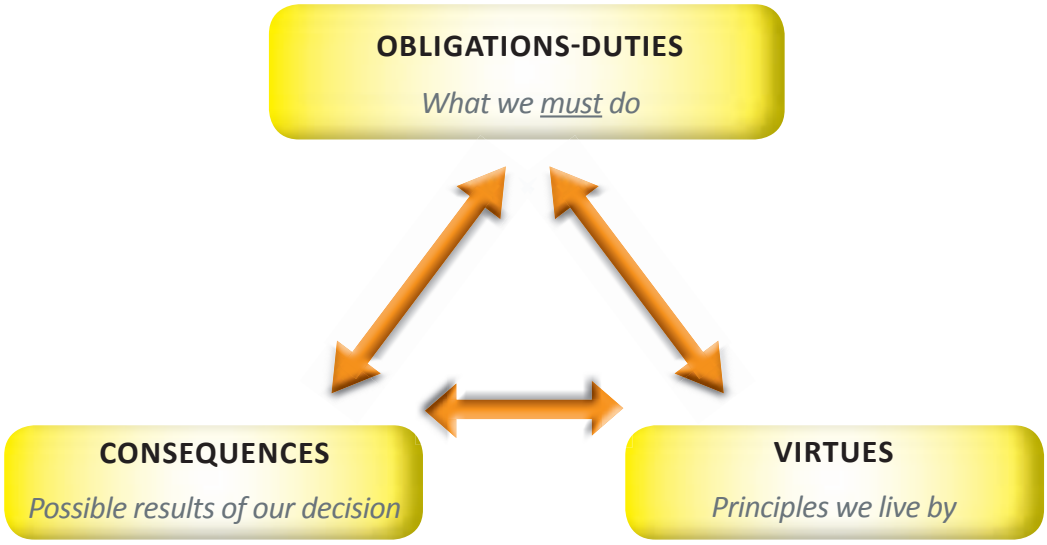

Figure 1: The Ethical Triangle[7]

to be gained from pre-emptively engagingly the enemy. Lastly, from the virtues perspective, it is up to CPT Ng's personal conviction and his ability to live with his actions thereafter. These three factors will guide his eventual actions.

In such morally ambiguous scenarios, our Gunners can rely on tools such as the Ethical Triangle, but need the space to do so. The SAF must empower them to decide for themselves, given that the rules-based military hierarchy could be perceived to favour compliance over independent thinking. Discipline and individual empowerment are not mutually exclusive. Where there are established codes of conduct, rules of engagement and standard operating procedures, our Gunners should behave in accordance with the prescribed rules. But there will be grey areas in operational situations, where the rules are silent, not sufficiently clear, or even contradictory. The organization should entrust our Gunners to exercise their individual discretion.

The ability to make carefully considered ethical decisions does not happen by chance, and must be systematically developed. Therefore, the SAF must equip our Gunners with the necessary moral competencies. Based on the Ethical Triangle, we should develop our Gunners' understanding of their obligations as military professionals, their ability to weigh the consequences of their decisions, and their awareness of personal values. The intent is for our Gunners to internalize these moral competencies to the extent that they consistently govern their conduct under even adverse combat conditions.

HQ SA

Exercising Individual Ethics

To this end, the SAF should continue to integrate military ethics into our training programmes. Research on the Swiss Armed Forces has shown that short-term courses are effective in developing competencies for moral decision-making.[8] Likewise, the SAF may offer courses on military ethics—teaching our Gunners about existing laws and conventions will raise awareness for their obligations in war; giving practical skills to deal with dilemmas will help them better consider the consequences. In the context of the Artillery, relevant case studies, such as past atrocities arising from Fire Support, contemporary examples of drone strikes, or hypothetical future scenarios, could be woven in. This would begin a conversation on the ethical realities facing us as Gunners, allowing us to reflect and build upon our moral foundations. Furthermore, as moral competencies tend to decline over time,[9] it is important to embed ethics within our everyday training, beyond one-off programmes. For example, we could introduce ethically challenging scenarios into field exercises and after-action reviews. By providing practical examples for discussion, commanders help their men to bridge the gap between abstract moral standards and their operational actions.

During operations, however, there is an inevitable tendency for individuals to revert to ethically inappropriate behaviour due to the stresses of combat. The SAF could conduct anonymous mental health questionnaires on our troops to better support them.[10] If ethical violations are discovered, the SAF is obligated to punish those who have committed war crimes. But more importantly, we should investigate and address the underlying factors, such as combat stress, anger over unit casualties, or a poor command culture that failed to emphasize ethics or stifled open reporting.

Ethical Tactics. At the tactical level, the Artillery must incorporate ethical considerations into the entire targeting process to guard against the unintended consequences of our fires. In planning targets to strike, sensitive sites such as schools, mosques and cultural sites should be avoided. In populated areas, it is especially important to obtain accurate and precise target location data in order to ensure the safety of non-combatants. There should also be sound weapon-to-target matching to ensure that the targets are engaged in a proportional manner and minimize collateral damage arising from target overkill. As an extension, we could consult military lawyers and civilian groups to check for blind spots. For example, the Pentagon had adopted this process in creating a Joint Target List for the 2003 Iraqi invasion.[11]

During the execution of targeting operations, there is also a need to emphasize process discipline so as to prevent ethical mistakes. Gunners must constantly check against the approved target lists and other fire support coordination measures that designate the allowable limits of fires. While our systems may automate these checklists, there should be human intervention at critical junctures. If a target contravened these boundaries but is assessed to be militarily necessary, we should seek approval for the strike mission from suitable authorities to ensure accountability. During the 2003 Iraqi invasion, such missions had to be approved by senior United States (US) civilian leaders.[12]

At the tactical level, the Artillery must incorporate ethical considerations into the entire targeting process to guard against the unintended consequences of our fires.

Commanders should also be equipped with sufficient battlefield situational awareness to help them assess the larger impact of their decisions. While individual strike targets might be proportional and ethical, they could have unintended effects when seen in totality. This will be enabled by C4ISR improvements, but we should not downplay other sources of information. Scenario 2, for example, showed how CPT Ng's appreciation of the overall battle picture had enabled him to potentially avert an unfortunate outcome.

After a target has been engaged, the SAF could consider sending "civilian casualty response teams" to manage the follow-on issues.[13] The teams should

have a wide range of expertise, such as medical personnel, information officers, munitions disposal specialists, military lawyers and intelligence experts. Such response teams can evaluate the impact of military operations on the civilian population, in a way that typical Battle Damage Assessments (BDA) might not. Their findings may be used to refine targeting tactics, techniques and procedures, and assist in criminal investigations if mistakes occur.

Strategic Perspective. Amidst advancements in warfare, some of the fundamental age-old rules of war remain valid. Singapore must continue to adhere to internationally accepted legal frameworks in order to retain her legitimacy in a post-conflict scenario. In a prolonged conflict, popular support will also be critical in winning the hearts and minds of non-combatants. With the media being so pervasive in today's military operations, any signs of unethical conduct by the SAF could easily be blown out of proportion. To achieve a strategic victory, all aspects of the SAF's military campaign must be above board.

The Artillery should integrate our strike operations with the rest of the SAF to ensure that ethical imperatives have been met in the overall battle strategy. An example of such integration can be seen in the US military's offensive against Al Qaeda in Tal Afar in 2005, where great effort had been made to minimize civilian casualties.[14] Prior to the offensive, civilians in affected areas were informed to evacuate, while those in other parts of the city were directed to remain in their homes. Air strikes and Artillery struck insurgent defensive positions using Precision Guided Munitions, and with persistent eyes on targets. Strikes were also timed to minimize the risk to non-combatants. This laid the way for the main ground offensive by US and Iraqi forces. As a result of synchronization at the strategic level, civilian casualties were greatly reduced.

Open Questions. While the trends of future warfare necessitate a return to fundamental ethical principles, they also open up several unexpected challenges. For one, removing humans from the battlefield could desensitise the public to the human deaths on the frontline, as society could perceive wars to be fought among machines rather than people. We see signs of this today—although the US drone war in Pakistan has caused hundreds of civilian casualties, domestic support largely remains strong. Without the same risk to human lives, the political cost of military action could be lowered. In a future where unmanned strike systems fight head-to-head, states may have to exercise restraint to avoid escalating to war.

The increasingly sophisticated targeting systems will also be able to process a far more complex set of engagement protocols and at much higher speeds than what humans are capable of. We expect more automated and intelligent systems without a man in the loop. But what if the system goes wrong? Who is to blame for any unintended consequences? Should the commander who oversaw the targeting mission be held responsible? Or the engineers who created the system and may have overlooked the defects? Does this also make us less sensitized, because we can blame the machine instead? Referring to Scenario 1, LTA Lim faces such a situation, if he decided to override the automated protocols of the U-FOs but inadvertently engaged actual civilians. On one hand, LTA Lim, as the commander, arguably failed to take feasible precautions. On the other, to punish him could, from a legal perspective, be placing more trust in the judgement of the computer than in the human actually at the frontline. Indeed, today's military laws may not be sufficiently nuanced to assign legal responsibility for unintended errors inflicted by automated systems.[15]

While the future operating context brings about a new set of ethical challenges, it is interesting to note the potential for unmanned technologies to make the conduct of war more ethical amidst a more complex battlefield. In 2007, the US Army commissioned a study of how a lethal autonomous system could be build with an ethical reasoning system, and concluded that that robots may not

just be "perfectly ethical in the battlefield," but more ethical than "human soldiers are capable of."[16] Unmanned autonomous systems, such as the U-FOs in Scenario 1, do not suffer from combat fatigue or emotional influences that could cloud judgment. Smart weapons that can distinguish between different targets, may also give the ability to only shoot at hostile combatants. Tapping on these opportunities will be equally important as addressing the attendant ethical challenges in future warfare.

CONCLUSION

Military ethics is not an excuse for the SAF to go soft—it is of strategic importance, as popular support and international legitimacy will be crucial to Singapore's survival post-conflict. The importance of ethics in fires will grow, given that the burden of ethical decisions will increasingly fall on those who conduct strike operations, especially at the lower echelons. Our capacities to grapple with these issues must thus evolve. Each Gunner must not only internalize his ethical and professional duties, but must have the moral courage to make the right stand. The Artillery should empower and equip them to do so. In the course of targeting operations, the Artillery must also put in place processes to guard against ethical mistakes as well as enforce system discipline. Collectively, the various arms of the SAF, including the Artillery, should be well-integrated to run a military campaign that achieves the strategic ethical imperatives.

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FUTURE GUNNERS

By **CPT Shirlyn Neo**, **CPT Chen Zhiyu** and **CPT Brian Lee Kian Hong**

ABSTRACT

Due to environment changes and advancements in technology, the Singapore Artillery has changed in many ways. Gunners today are required to cope with much more complex operations. This essay will present three significant traits required of future Gunners—Professionalism, Tenacity and Commitment—and how they enhance the Singapore Artillery. The existing practices, training methodologies and personnel development strategies for developing future Gunners will also be discussed.

INTRODUCTION

The operating landscape of the Singapore Artillery has changed considerably due to social and demographic changes, and advancements in technology. The Artillery has harnessed a full suite of sensor and shooter capabilities in recent years and the challenge now lies in developing relevant and ready Gunners who are able to cope with the complexity of the future operating environment.

Although birth rates and demographic trends have fluctuated over the years, the SAF has taken manpower requirements into account and become more potent through advances in technology and the introduction of effective systems and platforms that need less men to operate.[1] Future Gunners are required to assume more challenging and demanding operational roles, cope with more complex operational scenarios, and make decisions in the face of combat stress and ethical dilemmas.

Changing social demographics and educational profiles of Singaporeans have also given rise to Gunners who are more educated and tech-savvy. They are more able than Gunners of the past in operating technologically advanced artillery platforms, and possess greater ability and potential in undertaking complex Artillery missions.

It is a challenge to formulate the right strategies to exploit the strengths and potential of the future generation to meet the uncertainties of the multifarious operational environment. This essay will share about three desired traits of future Gunners and their significance and relevance to the Artillery. It will subsequently discuss the existing practices, training methodologies and personnel development strategies that can be used to inculcate the desired traits in future Gunners.

TRAITS OF FUTURE GUNNERS

The Singapore Artillery is reputed for our ability to continually evolve and adapt to an ever-changing operating environment, and to deliver decisive and effective firepower that shapes the battlefield for mission success. Nonetheless, these successes will only be sustainable with the right values and character in our Gunners. We have identified professionalism, tenacity and commitment as the desired characteristics of a Gunner. These are the traits that are necessary for the Artillery to be ready for tomorrow's missions.

Professionalism: A Frame of Mind

> *"Professionalism is knowing how to do it, when to do it, and doing it."*
>
> *– Frank Tyger*

Professionalism in the context of the Artillery requires Gunners to deepen and broaden their knowledge in their specialized domains—Liaison, Fire Direction (FD), Field Artillery Target Acquisition (FATA) and Strike—to deliver the best outcomes in complex operational environments. Professionalism also equates to building trust and upholding credibility as fire support experts, as we continue to provide the firepower for the maneuvers' missions.

The Gunners' spirit is a manifestation of our commitment to the formation and future generation of Gunners should strive to excel in all aspects to contribute towards the success of the Artillery.

The price of error in Artillery operations is significantly high due to the lethality of heavy munitions and their wide area of impact. The shift towards urban warfare and precision fires requires Gunners to be responsible for the careful selection of munitions and the prudent use of firepower in built-up areas to limit collateral damage to friendly troops and civilians alike. By deepening our weapon expertise and broadening our battlefield situation awareness, both commanders and operators can thus make calculated and timely decisions for the delivery of precision fire in various complex operational scenarios.

The nature of indirect fire positions our liaison teams as the "eyes" for our weapon systems. It is therefore especially important that the Artillery maintains credibility for the delivery of timely and accurate fire support for maneuvers. To achieve mission success, forward observers and fire support coordinators must understand both the capabilities of our assets and the operating procedures used in the maneuvers before they can provide professional advice during the planning stage.[2]

Tenacity: The Will to Fight

> *"The tempering of steel is a lengthy process and men of steel you must be, anything less has no place in the Singapore Artillery."*
>
> *– Dr Goh Keng Swee*

Throughout history, Artillery gunners were typically required to be strongly-built and physically tough for the manual operation of cannon and munitions. Despite today's automated rocket and gun systems, the notion of "Men of Steel" remains relevant as the new generation of Gunners now face more complex operations and greater demands than ever before. Tenacity continues to be an important characteristic in the Artillery, as we remain unyielding in our pursuit of engineering deadly and accurate fires and yet adaptable to meet the demands of today's multi-faceted operational environment.

Gunners must have the will to fight. As high value targets in the battlefield, Gunners need to react swiftly to commands and exploit opportunities that are critical to mission success and their survival. For example, the shoot-and-scoot concept requires the constant movement and deployment of the PRIMUS and HIMARS systems to engage targets of opportunity while ensuring sustainability of operations and battlefield survivability. Artillery radar operators must also possess great mental resilience and heightened situational awareness to respond to incoming threats constantly, as exemplified in our ARTHUR detachment crew during Operation Blue Ridge (OBR). Gunners must understand the importance of Artillery to the broader battlefield, upon which failure is not an option.

On the other hand, the adaptability is also key to being effective war fighter for future operational and peacetime requirements.[3] Gunners need to be steadfast, yet flexible to take calculated risks and to employ the optimal sensor-shooter combination to achieve the desired effects. The uncertainties of the dynamic operating landscape will demand Gunners that can remain cool-headed, yet resolute, who can then transit well into meeting the demands of Operations Other Than War (OOTW), as they possess the tenacity to push

new frontiers and are versatile enough to participate in Peacekeeping Operations (PKO) and Peace Support Operations (PSO).

Commitment: At the Heart of it All

> *"You must capture and keep the heart of the original and supremely able man before his brain can do its best."*
>
> *– Andrew Carnegie*

Commitment is steadfast fixity of purpose and should be the deepest core of each Gunner's beliefs. In the Artillery, we seek to promote excellence and nurture a winning team, which is only sustainable through committed soldiers. The Gunners' spirit is a manifestation of our commitment to the formation and future generation of Gunners should strive to excel in all aspects to contribute towards the success of the Artillery. A committed Gunner will understand the importance of defense and is motivated to do his best. He is a highly engaged individual who actively seeks to represent the formation in both training and administrative initiatives, and influences others to promote a strong team of well-rounded Gunners.

Our streamlined fighting force will also require every individual Gunner to stay committed to one another, building upon trust and dedication to overcome future challenges and adversities together. The commitment put forth by Gunners will hence shape behavior and build a growing Artillery Formation that is united and respected by all.

INCULCATING DESIRED TRAITS

> *"The finest steel has to go through the hottest fire."*
>
> *– Richard Nixon*

The three key traits identified can be developed through current practices and other effective training methods. Gunners can deepen their competencies through a robust knowledge management system and develop operational mindsets through participation in realistic training exercises. A systematic approach to training methods can also enhance the adaptability and performance of our people, as they complete a well-developed training roadmap that cultivates their mental and physical endurance. Last but not least, a strong commitment towards formation-wide activities can groom a winning team with an indomitable Gunners' Spirit.

Developing Operationally Ready Gunners

The Singapore Artillery can strengthen its operational mindset by capitalizing on lessons learnt from training exercises and operations, to keep pace with fighting concepts and new capabilities. For instance, professionalism and operational readiness are emphasized through overseas live-firing exercises and deployments. Gunners are exposed to realistic and demanding operational requirements such as the handling of live ammunition and long deployment durations. Notably, the deployment of our Weapon Locating Radar (WLR) Detachment and Military Institution Trainers (MIT) in Afghanistan have also returned with valuable lessons from personal experience and the professional exchange of knowledge with international forces.

A good set of knowledge management (KM) methods can also enhance the learning process for all Gunners, as it takes a shorter time to fulfill training requirements and enables Gunners to undertake tasks of greater complexity with ease.[4] For example, our Artillery information and knowledge is validated or shared amongst the Regular Corps through the mandatory annual Artillery Proficiency Knowledge Test (APKT). It is a centralized program that allows Gunners of all ages and appointments to maintain currency and promote a culture for constant professional learning.

Periodic review and documentation of our training systems is also necessary. The Artillery WOSPEC Corps pioneered the training development roadmap known as the Masters Program. The initiative is based on the Master Gunner concept that aims to develop professional WOSPECs who are imbued with core knowledge and vast experience across various specialized domains. It envisions the end state of a dynamic WOSPEC Corp as the custodian of training standards and enforcer of soldier fundamentals, inspiring a transformation for the future generation of the Artillery. The

Subject-Matter-Experts (SMEs) of the Artillery can also bridge knowledge gaps and build a robust partnership with the Officer Corps.

Molding Men of Steel

The Artillery formation seeks to develop a wide range of skills and competencies in our Gunners and to build enduring men of steel who are resilient yet adaptable.

Gunners from the Artillery Battalions are now trained via their unique Unit Training System (UTS), as compared to the previous common platform strategy. The Mission Essential Task List (METL) has been reconstructed according to the particular unit's operational capabilities and requirements. It will drive the different functional groups within the Battalion to reach their potential and achieve the unit's operational goals in the short span of an NS full-time obligation. A firm grounding in Soldier Fundamentals (SOFUN) is essential for Gunners before they can undertake more complex tasks.[5] Gunners are also evaluated on their Battery and Battalion proficiencies during the Field Artillery Training Evaluation Program (FATEP), which drills them on both knowledge and proficiencies in their operational roles. The completion of their competency roadmap will sharpen their soldier fundamentals and mould their resilience.

The formation can also improve training methods that enhance the adaptability and performance of our troops. Training for multiple scenarios is necessary to complement the broader spectrum of future operations and build mental resilience amongst Gunners. A framework that guides commanders in their analysis of operating environments and models for variables analysis and decision-making could be explored.[6] For instance, the United States Army's Military Decision-Making Process (MDMP) classifies conditions on the training grounds by operational and military variables which eventually help to define the operating environment for each soldier.[7] This provides a systematic view of the operational situation before the mission type and decision-making method are employed. The soldiers are then given due discretion for their decisions before the commander's feedback, allowing for greater flexibility and self-awareness. The Artillery can adopt such systematic approach in training Gunners to adapt swiftly on unfamiliar ground and develop mental resilience for problem solving.

Notably, the Artillery formation has also been exposed to a myriad of SAF and nationwide events, such as the SAF Day Parade, which have put our resilience to the test. Despite being a steamlined force, the Artillery has been able to form competent teams that have performed beyond their work scope and contributed too many successes. In the same vein, the Artillery will strive to make the Opening Ceremony for South-East Asia Games 2015 a resounding success.

Nurturing the Gunner's Spirit

The Artillery family celebrates and reinforces the Gunners' Spirit through engendering commitment to formation wide activities. This spirit is forged not only during training exercises and operations, but also through informal gatherings and competitions. Over the years, these events have become an integral part of the formation that unites the family as one, promoting a strong culture for excellence and a winning team.

It is important to recognize our Gunners' achievements and personal growth within the formation, as it enhances their optimism and belief in defense.

The Gunners' Rendezvous (RV) is a tradition held on the first Friday of every quarter of the year as a gathering of the young and old Gunners to congregate and forge new bonds. It includes NS commanders, retired Gunners and the Regular Corps who come together to share their experiences and to rekindle kinships forged through the formation. In addition, the annual Men-of-Steel Challenge as part of the formation's anniversary celebration is a highly anticipated event. It brings forth the very best in our Gunners, as battalions strive to compete against one another with their professional skills, physical strength and teamwork. Beyond that, it is an opportunity to engender commitment towards the formation and to promote excellence amongst Gunners.

It is important to recognize our Gunners' achievements and personal growth within the formation, as it enhances their optimism and belief in defense. The Artillery leadership needs to continue to give recognition and empowerment to our future Gunners to further promote and sustain the Gunners' Spirit as we celebrate the excellence in the formation.

CONCLUSION

The Singapore Artillery has introduced a series of weapon systems over the past decades that are more sophisticated and deliver deadlier and more accurate fire. Our current generations of Gunners have great potential to operate these new capabilities. However, the future operational environment will be more complex and demands that the Artillery do more with a streamlined force. Bearing this in mind, the formation continues to seek relevance for our Gunners through cultivating desired traits such as Professionalism, Tenacity, and Commitment, to be ready for tomorrow's missions.

To develop operationally ready Gunners, we seek to deepen their competencies via a robust knowledge management system, utilizing practices such as the APKT and the Masters Program. The knowledge and operational mindset can also be strengthened through participation in realistic training exercises and adopting lessons learnt from operational deployments. To mould 'Men of Steel' who are resilient yet adaptable, we have adopted a sustainable framework to hone proficiencies and knowledge through a structured METL. The timely completion of competency roadmap also cultivates the Gunners' mental and physical endurance, which will enhance their adaptability and performance in operations. At its very core, strong commitment towards the formation can lead to the growth of a winning team with an indomitable Gunners' Spirit. Commitment can also be influenced through inspirational leadership and recognition from others. Professionalism, Tenacity and Commitment go hand in hand towards developing our future Gunners, who will continue to be "Men of Steel" in the modern complex battlefield.

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ABOUT THE AUTHORS

EVOLUTION OF FIRES: HOW FIRES CAN STAY RELEVANT ON THE MODERN BATTLEFIELD

CPT Edwin Lee Wen Jun is a Staff Officer in the Defense Policy Office. CPT Lee was a recipient of the SAF Overseas Scholarship. In 2008, he graduated from the University of Michigan summa cum laude with a Bachelor of Science in Electrical Engineering. He went on to obtain a Master of Science in Engineering Management from Columbia University in 2009.

LTA Kwan Siew Ling is a Gun Positioning Officer in 21st Battalion, Singapore Artillery. She graduated from the University of New South Wales in 2009 with a Bachelor of Science in Pharmacology.

EXCELLENCE IN PRECISION FIRES: HOW TO AVOID BEING PRECISELY INACCURATE?

CPT Lim En is a Staff Officer in the National Service Directorate. CPT Lim was a recipient of the SAF Merit Scholarship. She graduated from University of Chicago in 2010 with a Bachelor of Arts in Economics. She went on to obtain a Master of Philosophy in International Relations from Cambridge University in 2011.

CPT Daryl Tay Wei Jin is Head of System Trial Section at Headquarters Singapore Artillery. CPT Tay was a recipient of the Local Study Award. He graduated from the National University of Singapore in 2008 with Second Class Honors (Upper) in Sociology.

PIERCING THROUGH THE FOG OF WAR WITH C4ISR-STRIKE

MAJ Kwek Kian Leong is a Project Officer in G5-Army. MAJ Kwek was a recipient of the SAF Merit Scholarship. He holds a Bachelor of Science in Aerospace Engineering and a Master of Science in Industrial and Operations Engineering from the University of Michigan.

CPT Lam Li Wen is a Battery Fire Direction Officer in 23rd Battalion, Singapore Artillery. CPT Lam was a recipient of the SAF Merit Scholarship. She graduated from University College London in 2011 with a Bachelor of Arts in Geography. She went on to obtain a Master of Science in Public Service Policy and Management from King's College London in 2012.

CPT Chan Yen Shun is an In-Camp Training Planner at the Artillery Reservist Training Centre. CPT Chan was a recipient of the SAF Academic Scholarship (Local). He graduated from Nanyang Technological University in 2009 with a Bachelor of Science in Mechanical Engineering.

CPT Edwin Cai is a Liaison Trainer at the Tactical Fires Center, Artillery Institute. CPT Edwin was a recipient of the SAF Academic Scholarship (Local). He graduated from Nanyang Technological University in 2012 with a Second Class Honors (Upper) in Chemistry and Biological Chemistry.

FUTURE ARTILLERY FIRES

CPT David Kwek is a Force Transformation Officer in the Joint Plans and Transformation Department. CPT Kwek was a recipient of the SAF Overseas Scholarship. He graduated from Imperial College in 2011 with a Master of Engineering in Electrical and Electronic Engineering.

CPT Lim Wee Yeow is a Battery Commander in 23rd Battalion, Singapore Artillery. CPT Lim was a recipient of the SAF Academic Scholarship (Overseas). He graduated from University College London in 2012 with a Master of Engineering in Chemical Engineering.

ETHICS IN FIRES

CPT Mikail Kalimuddin is a Staff Officer in Force Plans Branch, G5-Army. CPT Kalimuddin was a recipient of the President's cum SAF Overseas Scholarship. He graduated from Brown University in 2009 with a Bachelor of Arts in Economics and Political Science and a Master of Arts in Economics.

CPT Hong Wenxian is a Staff Officer in the Joint Manpower Department. CPT Hong was a recipient of the President's cum SAF Overseas Scholarship. He graduated from Massachusetts Institute of Technology with a Bachelor of Science in Mechanical Engineering in 2009 and a Master of Science in Mechanical Engineering in 2010.

FUTURE GUNNERS

CPT Shirlyn Neo is currently a Staff Officer in G1-Army. CPT Neo was a recipient of the SAF Academic Scholarship (Overseas). She graduated from University of Warwick in 2012 with a Bachelor of Arts in Sociology.

CPT Chen Zhiyu is a Battery Recce Officer in 21st Battalion, Singapore Artillery. CPT Chen was a recipient of the SAF Academic Scholarship. He graduated from McGill University in 2013 with First Class Honors in Biochemistry.

CPT Brian Lee Kian Hong is a Battery Commander in 21st Battalion, Singapore Artillery. CPT Lee was a recipient of the SAF Academic Scholarship. He graduated from University of Queensland in 2012 with First Class Honors in Molecular Biotechnology.

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