COST-EFFECTIVENESS AND UTILISATION OF AIR POWER IN FOURTH GENERATION WARFARE

VIVEK KAPUR

INTRODUCTION

Since air power made its advent on the battlefield about a century ago, it has come to occupy a pivotal position in the execution of warfare. With the passage of time, increasing capabilities have made air power ever more potent and also much more expensive to acquire and utilise. The changing nature of modern conflict calls for a relook at the design, equipping, and optimal utilisation philosophies for the air forces to remain effective in modern warfare.

The trend discernible in modern warfare is such that in most cases, at least one of the parties in the conflict may not be a state with conventional armed forces but a non-state entity or a proclaimed state, such as the Islamic State (IS) which has declared itself to be a state, but lacks the conventional military and other infrastructure common to nation states, as we understand the term. This change calls for a reassessment of the means of fighting such wars. This paper uses primarily the US and Western examples to highlight points due to the best availability of data on Western weapon systems.

Group Captain **Vivek Kapur** is a Senior Fellow at the Centre for Air Power Studies, New Delhi.

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EVOLUTION OF MODERN MILITARY AIRCRAFT

Early military aircraft were grouped into specialist roles as bombers, aircraft designed to deliver ordnance on surface targets, and fighters, which were designed to seek out, engage and shoot down other aircraft. This division was forced by the then prevailing limitations of technology that was at the time unable to provide both capabilities in the same airframe. In the years since the end of World War II (WW II), advances in technology enabled the provision of both air-to-air and air-to-ground capabilities on a single aircraft. This move led to the then new designation in military aircraft: the 'fighter-bomber'. Early fighter-bombers required to be prepared for the air-to-air or the air-to-ground mission before taking to the air. Thereafter, the aircraft was restricted for that mission, to that role alone. Valid military demands for more flexibility along with further technological breakthroughs led to incorporation of capabilities wherein the fighter-bomber could undertake both missions in the same sortie. This new capability was first evident in the US Navy's (USN's) and US Marine Corps' (USMC's) F/A-18 "Hornet". McDonnell Douglas Corporation, capitalised on this new capability with full page advertisements in aviation journals touting the F/A-18's ability to carry adequate air-to-ground as well as air-to-air ordnance with minimal degradation in performance while being able to switch between air-to-ground and air-to-air missions at the flick of a single switch in the cockpit.[1] The F/A-18 in its generation embodied the best illustration of the ability to combine both air-to-air and air-to-ground roles in the same airframe. Bombers, especially heavy bombers, were fielded from the 1970s onwards primarily by the two superpowers, the US and Soviet Union, later Russia, and by China. Most

1. See, "The Versatile McDonnell Douglas FA-18 Hornet was Used by the USN and USMC to Succeed a Variety of Aged Carrier-Based Fighting Aircraft", URL: http://www.militaryfactory.com/aircraft/detail.asp?aircraft_id=57. Accessed on December 3,.2014.

bombers in service with the two superpowers came to be regarded as 'strategic bombers' based upon their range and payload ability, and acknowledged nuclear attack tasking. The US has retained its strategic attack capability based upon manned bombers even after the demise of the Soviet Union as has Russia, the Soviet Union's successor state. Bombers have been used operationally by the US in tactical roles in Iraq, Afghanistan and Kosovo.[2] Russia continues to operate its bombers though these are mostly utilised in "show the flag" missions in international air space but close to the North Atlantic Treaty Organisation (NATO) countries' borders[3] and in the Pacific Ocean areas to showcase its military might.[4]

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The US commenced development of Low Observable (LO) or stealth technology to defeat Soviet air defences but retained this technology even after the end of the Cold War, despite the very high cost of the technology; costs resulted in just 21 B-2 "Spirits" being finally built. The new cutting edge US fighter, the F-22 "Raptor", designed to successfully penetrate the Soviet Union's dense air defences through use of its advanced LO technology continued to be developed even after the end of the Cold War. The total production run of this aircraft was finally capped at 187 due to the very high cost per unit. The follow-on fighter meant to replace a large number of earlier fighters in the US as well as in the air forces of its allies, the F-35 "Lightning-II", continues to be developed towards entering active squadron service. This fighter has suffered consistent time slippages as well as cost overruns. Fielding of these LO aircraft, in terms of fighters as well

2. Marcus George, "Profile: B-52 Bomber", *BBC News,* http://news.bbc.co.uk/2/hi/americas/1632521.stm. Accessed on November 18, 2014.
3. Chris Johnston, "RAF Intercepts Russian Bomber Approaching UK Airspace", *The Guardian,* http://www.theguardian.com/uk-news/2014/nov/01/raf-russian-bomber-uk-airspace Accessed on December 3, 2014.
4. "Long-Range Air Patrols put Russian Strategic Bombers near Guam", URL: http://rt.com/usa/207783-russian-bombers-planes-guam/. Accessed on December 3, 2014.

as bombers, has enabled the US to maintain an unassailable technological advantage over all its potential adversaries. This has been accomplished at the cost of reduced force levels in numbers and very high costs in the development as well as operation of these aircraft. To put these figures in perspective in the Indian context, the Indian Air Force (IAF) contracted with Israel for three Phalcon Airborne Warning and Control System (AWACS) for a total cost of $1.1 billion for all three aircraft.[5] A quick comparison puts the cost of one US Fifth Generation (Gen 5) fighter (see Table 1), at close to, actually a little higher than, that of a Phalcon AWACS in the IAF's service.

The underlying common factor is that all these LO aircraft were developed for a conventional war scenario as it prevailed in the mid to late 20th century. In Western Europe, fighter developments have not gone for fully LO designs such as the F-22, F-35 and B-2 but have tried to reduce signatures to a lesser extent while incorporating advanced sensors and swing role capabilities. The most recent advanced combat aircraft from Western Europe, the French Rafale and multi-national Eurofighter Typhoon, feature swing role capabilities and reduced signatures short of LO technology application as seen in US fighters. As a result these two European fighters, though not as expensive as the F-22 and F-35, still cost a considerable amount. Costs of purchase and operation of several modern fighter aircraft are placed below at Table 1.

The high purchase and per flight hour costs of the most modern Western fighters and the B-2, built for conventional warfare, fall more into perspective if seen against the same parameters for the previous generation of fighters from these Western countries (the F-16s, F-18s, and F-15s, for their latest versions in the early 21st century). In sharp contrast, fighters from non-Western sources are much cheaper to purchase as shown by the unit costs of the MiG-21-93 at $ 27 million and the newly built Russian Sukhoi Su-30MKs at $ 50 million each. The MiG-21-93 and Su-30MK feature no LO. These older technology MiG and Sukhoi fighters from non-Western sources could be expected to have limited survivability in aerial combat against fighters that feature LO technology and

5. Rajat Pandit, "India to Launch AWACS Project to Counter China, Pak", *The Times of India* (New Delhi), http://timesofindia.indiatimes.com/india/India-to-launch-AWACS-project-to-counter-China-Pak/articleshow/14253161.cms. Accessed on December 3, 2014.

could reasonably be expected to have greater vulnerability than advanced LO fighters to modern anti-aircraft defences. That apart, these aircraft can get most other tasks of combat air power done at a much lower cost, especially if operating in a relatively permissive air environment where an opposing air force is either non-existent or of a much lower capability and, hence, unable to interfere in any major manner with one's own air operations.

Table 1: Unit and Operating Costs of Modern Fighters

Aircraft Type	**Purchase cost per unit in $ million**	**Operating cost per hour of flight in $**
Typhoon	199	18,000
Rafale	102.6	19,000
F-22	420	61,000
F-35A / B / C	181 / 252 / 299.5	Not Available (NA)
B-2	2200	135,000
Aircraft Type	**Purchase cost per unit in $ million**	**Operating cost per hour of flight in $**
F-16 latest versions	30	7,000
F-18 latest versions	67	11,000-14,400
F-15 latest versions	100-108	28,000-30,000
A-10	20	17,716
MiG-21-93	27	NA
Sukhoi Su-30MK	50	NA
Su-25	13-15	NA

Source: David Noland, "Bombers: Northrop B-2", http://www.infoplease.com/spot/northropb2.html. Accessed on November 10, 2014.
Ralph Vartabedian and W.J. Hennigan, "F-22 Program Produces few Planes, Soaring Costs", *Los Angeles Times*, http://www.latimes.com/business/la-fi-advanced-fighter-woes-20130616-dto-htmlstory.html. Accessed on November 17, 2014.
"How Much the F-35 Really Cost?", *Defense Update News*, http://defense-update.com/20140103_much-f-35-really-costs.html#.VGrQssl1eZQ. Accessed on November 9, 2014.
"Military Aircraft Costs", *Defense Issues, Defense News and Analysis,* https://defenseissues.wordpress.com/tag/eurofighter-typhoon-cost/. Accessed on November 11, 2014.

Older Western aircraft costs are also useful for an understanding of the costs of advanced LO aircraft. The US A-10 "Thunderbolt" is a role specific Close Air Support (CAS) aircraft similar in performance to the Soviet, Su-25, an equivalent dedicated CAS fighter. The per hour cost of operation is

not available for this type as is the case for most Soviet or Russian aircraft.

While the A-10 and Su-25 were specialised dedicated aircraft for close air support operation to friendly land forces in close contact with enemy land forces, the ultimate in this close air support operation of air and land forces is the armed and attack helicopter. Unlike fixed wing aircraft, the helicopter flies at much lower speeds and, thus, is able to persist in the area for much longer while having more time to acquire fleeting targets in the turmoil of the tactical battle area. The helicopter's ability to land even on unprepared level surfaces enables greater coordination with the friendly land forces involved. The first armed helicopters were used by French forces in their operations in Indochina. The AH-1 Huey Cobra was purpose built as an attack helicopter and entered active combat service in 1967 in Vietnam.[6] The Soviets developed armed variants of the Mi-8 utility helicopter and later the Mi-24/25 "Hind" dedicated attack helicopter. The European Union (EU) developed the Tiger attack helicopter while China and India have developed the Z-10 and Light Combat Helicopter (LCH) respectively.

These developments bring out that since its advent, the armed, and more so the attack, helicopter has proven its worth in land combat, driving new developments in the field. In the current operations against the Islamic State (IS) by the coalition led by the US, the US Army AH-64 "Apache" helicopters based at Baghdad airport have been used alongside Russian supplied Mi-35M attack helicopters of the Iraqi Army.[7] In the kind of situation being faced in the current military operations against the IS, the attack helicopter is a very potent and suitable weapon system. The attacks against the IS comprise basically attacking relatively small groups of foot soldiers, at most mobile on pick-up trucks and similar commercial vehicles, and armed primarily with personal infantry level weapons. The IS forces lack the heavy armament typical to conventional armies and look more like irregular guerrilla forces than anything else. In such circumstances,

6. Ibid.
7. James Rush, "ISIS Air Strikes: US Brings in Apache Helicopters as British Jets Target Militants in Iraq", *The Independent*, http://www.independent.co.uk/news/world/middle-east/isis-air-strikes-british-jets-carry-out-latest-attack-on-militants-in-iraq-9777284.html. Accessed on December 2, 2014.

conventional military air power is bereft of lucrative targets such as artillery, Multiple Launch Rocket Systems (MLRS), armoured vehicles, etc. The attack helicopter, due to its proximity to the combat area, could be more effective in locating, tracking and effectively engaging these forces as compared to conventional fixed wing aircraft.

The helicopter does, however, suffer from a major drawback. It is relatively slow and very vulnerable to surface fire, even from small arms. Being slow moving and designed to operate in close proximity to surface forces, the helicopter is also very vulnerable to Low Level Quick Reaction Missiles (LLQRMs). LLQRMs, captured from Iraqi Army stocks, along with machine guns of various calibres, are known to be in the possession of the IS.[8] There are reports that IS fighters have shot down Iraqi Mi-35M attack helicopters with these LLQRMs, despite the Mi-35M's self-defence suites[9]. Hence, the use of attack helicopters carries a possible cost in potential losses of aircraft and their crew.

The alternative is to utilise Remotely Piloted Aircraft (RPA) such as the US MQ-9 "Reaper" and the MQ-1 "Predator". These RPA are able to surveil large areas effectively due to their long endurance and with a man in the loop, in the form of the controller who could be located anywhere in the world while using Satellite Communication (Satcom) to keep in contact with his RPA, and engage identified targets through the "Hellfire" missiles carried onboard the RPA. Both the Predator and Reaper are analogues of the earlier armed attack helicopters in that these are essentially reconnaissance machines adapted to an armed attack role.[10] Purpose designed attack RPA continue to be under development in many parts of the world. The RPA has major advantages over even the attack helicopter. The first of these is that the RPA removes friendly humans from the battlefield more than the attack helicopter, a manned machine, does. The RPA can carry out search and strike attacks by day as well as by night, with its operator as far away as on the

8. "ISIS Fighters Seen with Advanced Antiaircraft Missiles", *Al Arabiya News*, http://english.alarabiya.net/en/News/middle-east/2014/10/28/ISIS-fighters-seen-with-sophisticated-antiaircraft-missiles-.html. Accessed on December 2, 2014.
9. Ibid.
10. "Predator RQ-1 / MQ-1 / MQ-9 Reaper UAV, United States of America", http://www.airforce-technology.com/projects/predator-uav/. Accessed on December 3, 2014.

In this comparison of attack helicopters and RPA, the RPA is seen to be ahead in cases where loss of lives or PWOs situations are not acceptable.

other side of the globe from the area of operation. This has been amply demonstrated in the Predator and Reaper operations in Afghanistan, Yemen and Iraq. The attack helicopter conveys a level of shock and helplessness to ground forces at their receiving end. Modern attack helicopters carry very heavy armament comprising heavy machine guns, and large numbers of unguided rockets and guided missiles.

The helicopter is inherently a very noisy machine, and its approach can be detected, even in the absence of radars, through hearing its noise comprising the engine sound as well as the rotor beat. Advances in engine as well as rotor blade technology have been successful in reducing the helicopter's audio signature to some extent. The audio signature has not been, and may never be, eliminated completely. Even RPA have a distinct audio signature which, due to their altitude of operation and design, would be less of an issue than for attack helicopters. Hence, the approach of attack helicopters would in all probability be detected by the intended targets with adequate time to prepare LLQRMs and other weapons for defence against them. While the attack helicopters can deliver awesome firepower effectively against irregular forces such as were found in Afghanistan, Iraq and in current operations against the IS, it is only a matter of time before some are lost to enemy fire with concurrent loss of lives or Prisoners of War (POWs) situations developing. In this comparison of attack helicopters and RPA, the RPA are seen to be ahead in cases where loss of lives or POWs situations are not acceptable.

The attack helicopter has far greater ability to focus concentrated firepower on targets as it carries much greater armament than currently available armed RPA such as the Predator and Reaper. There are other advantages of having a man on the spot as no machine has yet been able to match the human ability for situation analysis and innovative reaction to dynamic situations.

Another limitation of the current armed RPA is that their slow speed and, hence, high transit time requires bases in the vicinity of the operations area

for them to operate from. Thus, RPA used in Afghanistan usually flew out of bases in Afghanistan or from neighbouring Pakistan as was the case in Iraq as well as Yemen.[11] The current operations against the IS in Iraq and Syria would require operating RPA from suitable bases in the region. Presently, candidate bases are likely to be available in Israel, Turkey, Jordan, Saudi Arabia, and other US allies, but this may not always be the case. The attack helicopter also requires basing in the area of operations, usually closer than an RPA, due to its limited radius of action. Ideally, the attack helicopter should operate in close coordination with troops or special forces.

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In view of these relative merits and demerits of the RPA and attack helicopter, it is apparent that there is merit in the use of each in isolation and in their close coordination with each other. In this context, the unfolding operations by the coalition led by US against the IS are likely to prove very interesting in giving pointers towards the likely path ahead. This aspect merits a revisit a few months, hence, by when empirical evidence should be available in the public domain to pursue the arguments for and against each of these two airborne weapon systems.

DEVELOPMENT OF MODERN AIR-TO-SURFACE WEAPONS

The first air-to-ground weapons ever used from heavier than-air-aircraft in 1911 were free fall bombs, initially just hand grenades.[12] Over the years from the first use of aircraft in hostilities till the late years of World War II

11. Nick Turse, "America's Secret Empire of Drone Bases", http://www.worldcantwait.net/index.php/features/covert-drone-war/7447-americas-secret-empire-of-drone-bases. Accessed on December 3, 2014.
12. "The War in the Air - Summary of the Air War", http://www.firstworldwar.com/airwar/summary.htm. Accessed on November 18, 2014.

the nature of the weapons used by aircraft against ground targets remained essentially unchanged in that these comprised machine guns and / or cannons[13] mounted on the aircraft along with unguided "dumb" or "iron" bombs that were basically free fall weapons. As the type of weaponry in use was entirely unguided, the number of weapons that required to be used to obtain the desired destructive effect on the target was large. This is the reason for the famous large bomber missions, going up to the British Royal Air Force's (RAF's) 1,000 bomber raids against Germany,[14] that were flown during World War II.[15] On October 14, 1943, the US Army Air Force's (USAAF's) Eighth Air Force mounted a 351-bomber raid to destroy the *Schweinfurt* ball bearing factory in Germany.[16] Despite the large number of bombers used, the factory suffered only a two-thirds drop in production and not total destruction. The USAAF bombers suffered 19 percent losses to enemy defensive action despite friendly US fighter escort being available.[17] The ability to deliver weapons accurately remained a human skill that could not be easily replicated. The need to destroy a target, hence, required a large number of weapons to be dropped on it in the hope that an adequate number would impact on it and cause the desired damage. There was need for accurate intelligence on the location, hardening, layout, etc. of targets for air-to-ground attacks to be successful.

Several new guided air-to-surface weapons were developed in this period spanning the 1950s to the mid-1970s. These included the US Air to Ground Munition (AGM)-12 "Bullpup", AGM-62 "Walleye", Guided Bomb Unit (GBU)-8, and the first Laser Guided Bomb (LGB), the Texas Instruments developed Bomb, Laser, and Terminal Guidance (BOLT) -117,

13. The difference between aircraft mounted guns and cannons essentially is that the former fire solid projectiles that have only a kinetic impact on the target while the latter fire rounds that incorporate an internal explosive charge that is designed to explode on impacting the target and, thus, to cause more damage.
14 "The Thousand Bomber Raid", http://www.historylearningsite.co.uk/thousand_bomber_raid.htm. Accessed on November 18, 2014.
15. V Kapur, "Precision Weapons in Aerial Warfare", http://www.idsa.in/issuebrief/PrecisionWeaponsinAerialWarfare_vkapur_080512.html. Accessed on November 17, 2014.
16. "World War II: Eighth Air Force Raid on Schweinfurt", http://www.historynet.com/world-war-ii-eighth-air-force-raid-on-schweinfurt.htm. Accessed on November 12, 2014.
17. Ibid.

later redesignated as the GBU-111. Its successors are today's Paveway-I, II, III and IV LGBs.[18] Earlier, such guided weapons mimicked the World War II vintage German "Fritz X" in incorporating a man in the loop command guidance with all its limitations. Later, autonomous guidance systems based upon electro-optical, Infra-Red (IR), laser and other parts of the Electro-Mmagnetic (EM) spectrum were developed.

An unavoidable characteristic of these new high technology weapons that enabled more accurate ground target attack through exploitation of the EM spectrum for target detection and guidance was high cost per weapon due to the incorporation of high technology, more precise high end manufacturing process requirements, and the Research and Development (R&D) costs involved. With newer developments that promise better performance, the cost of each weapon inevitably climbs even higher. A US Paveway-II LGB in the early part of this century cost $ 23,700 in a large production run.[19] A single US Mk-82 iron or dumb 500 lb bomb, in contrast, cost a mere $ 268.5.[20] The costs involved in a modern high technology war are very high. The 25-hour-long, covering a total of 11,418 miles, delivering a total of 45 x 2,000 lb satellite guided bombs, Global Positioning System (GPS) guided Joint Direct Attack Munitions (JDAMs) mission flown by three Whiteman Air Force Base, Missouri, USA-based USAF B-2 bombers against Libyan air defence targets in March 2011[21] would have cost merely $3,375,000 in the per hour flying cost of one B-2. The three aircraft formation of B-2s cost in dollar per flying hour totals up to $ 10,125,000. Each 2,000 lb JDAM itself costs $ 21,000[22]. Hence, the 25-hour-long mission that destroyed Libyan Air Force hangars and other ground infrastructure cost $ 945,000 for the 45 JDAM weapons used alone. This totals up to a full mission cost of $ 11,070,000, including the per hour

18. Kapur, n.15.
19. Ibid.
20. "Mk82 General Purpose Bomb", http://fas.org/man/dod-101/sys/dumb/mk82.htm. Accessed on November 18, 2014.
21. Richard Hartley-Parkinson, "Touchdown: B-2 Stealth Jets Return After Epic 11,500 Mile Journey to Bomb Libyan Aircraft Shelters", http://www.dailymail.co.uk/news/article-1368337/Libya-crisis-B2-stealth-bombers-25-hour-flight-Missouri-Tripoli.html. Accessed on November 18, 2014.
22 "GBU-38 JDAM", http://www.deagel.com/Bombs-and-Guidance-Kits/GBU-38-JDAM_a001074003.aspx. Accessed on November 19, 2014.

flying cost of the B-2s and the cost of all the weapons utilised. It is, of course, for the planners and their staff in the operating air force to determine if the cost of the mission was worth its benefit. To an outsider, with access to only open source information, the cost of the mission appears exorbitantly high and basically unsustainable given that in view of the relative obsolescence of the Libyan Air Force and its lack of any effective air defence capability in 2011, the desired effect could have been achieved through other less resource intensive means such as cruise missiles or earlier generation carrier or land-based aircraft already available in the Mediterranean Sea region.

The earlier US air attack on Libya in 1986 (Operation El Dorado Canyon) that utilised 1960s' vintage F-111s flying out of air bases in the UK, supported by a few US Navy carrier-based essentially electronic support assets took place at a time when the Libyan Air Force was much more coherent and effective than in 2011, but was successful despite non-availability of expensive LO aircraft albeit at the cost of one F-111 being shot down.[23] The loss of the lone F-111 cannot be attributed to just absence of high end LO capability in that mission. Even during the Gulf War of 1991, despite the great asymmetry in capabilities of the coalition aligned against Iraq and the Iraqi military, coalition aircraft that followed low low low (lo lo lo) level flight and attack profiles suffered relatively high losses to opposing anti-aircraft systems while medium medium medium (med med med) and high high high (hi hi hi) level attack profiles (predominantly by Gen 4 or earlier technology aircraft) were relatively unscathed[24]; The Operation El Dorado Canyon Libyan raid in 1986 followed a lo lo lo profile, thus, flying through even the engagement envelope of opposing air defence artillery systems. There is no information about the Libyan weapon system anti-aircraft artillery or Surface-to-Air Missile (SAM) that the ill-fated F-111 was shot down by in 1986. The B-2 raid on Libya was probably meant more as a demonstration of the long reach of the US Air Force's (USAF's) high end

23. "Op El Dorado Canyon", http://www.globalsecurity.org/military/ops/el_dorado_canyon.htm. Accessed on November 19, 2014.
24. Christopher Bellamy, "Britons Died in Gulf War 'Due to MoD Interference'", http://www.independent.co.uk/news/britons-died-in-gulf-war-due-to-mod-interference-1321938.html. Accessed on November 18, 2014.

hardware than for operational reasons that eliminated the possibility of less costly assets being used. Given the figures of weapon as well as per hour flight cost, as stated earlier in this paper, it is quite easy for the reader to work out the cost of similar missions by other Gen 5 or Gen 4 aircraft. This high cost per weapon delivered to the target makes the guided weapon cost-effective when used against difficult, well defended targets that could cost much more to attack if less capable and less costly weapons were used, thereby possibly endangering attacking aircraft, used in larger numbers to cater for the reduced accuracy of each weapon, and forced to fly closer to the target and each of which aircraft cost several million dollars.

In sum, modern costly guided weapons are best utilised in situations where not using them would result in the target not being attacked effectively and / or put expensive attack aircraft or lives in unnecessary jeopardy. Use of LO technology is best suited for situations where non-use of such aircraft may jeopardise the mission due to the presence of effective enemy air defences. It is unlikely that even the US would be able to sustain such expensive military operations for much longer in the near to medium term as we go into the 21st century.

CHANGING NATURE OF WAR

Since World War II, in the mid 20th century, the nature of predominant warfare has been changing in many ways. The post World War II years saw the emergence of two blocks of superpowers, the Warsaw Pact led by the erstwhile Soviet Union and the North Atlantic Treaty Organisation (NATO) led by the US. These blocks wielded irresistible military power as compared to other nations. In the era of a military balance, including a nuclear weapon fuelled deterrent posture between these two superpowers, inter-state military conflicts took place for the most part between the lesser powers of the world, often as proxies for the two superpowers. However, the bulk of conflicts since 1945 have involved non-state actors or insurgent groups acting against nation states. This trend towards the latter type of conflict has been growing at an alarming rate. The trend has spawned a new discourse on the nature of warfare with the current prediction being

that the world is seeing a transition towards Gen 4 warfare. These non-state forces typically lack any heavy military equipment and combat air power. They comprise predominantly lightly armed irregular 'foot soldiers' who indulge in guerrilla campaigns, presenting no major targets such as regular military forces have in terms of command headquarters, logistics nodes, logistics lines, heavy equipment (armoured vehicles and heavy artillery) locations, bridges, factories, etc. to attack. Even their leadership is diffused and 'widely distributed' in the sense that there is no known location for the seat of leadership or a very clearly specified hierarchy at the upper levels of the leadership that can be located and targeted. The density of fighters per unit area is also quite low as compared to conventional military forces as the latter rely upon massed firepower for achievement of objectives while the non-state forces operate as an amalgamation of light raiding parties more than anything else. In sum, the new nature of fighters that are being seen emerging in many parts of the world—the Naxalites (Maoists in India), the Taliban in Afghanistan, Kurd forces in northern Iraq, northwest Iran and southern Turkey and now the Islamic State (IS), earlier the Islamic State of Iraq and Levant (ISIL)—are seen to conform to this new nature of opponents that nation states are facing. Since 1945, there have been approximately 160 armed conflicts in the world of which as many as 75 percent have been Low Intensity Conflicts (LICs), which have taken place generally in less developed parts of the world and have mostly involved regular military forces on one side, fighting guerrillas, terrorists, and even women and children, on the other. Despite being low technology in nature, LICs have been very bloody, causing significantly more casualties than conventional wars since 1945. In the years since 1945 till date, only LIC has resulted in change of borders. Even in the 1971 Indo-Pak War which created the new state of Bangladesh, the result was in large part the outcome of the indigenous Bangladeshi Mukti Bahini (an irregular insurgent force, weakening through guerrilla attacks, and continually harassing, the Pakistan Army in erstwhile East Pakistan and, thus, assisting the advance of the Indian Army. Hence, the results of the 1971 Indo-Pakistan War cannot be attributed to conventional war alone. The results of such border changes are usually recognised by the

same international community that frowns upon conventional wars aimed at redrawing boundaries. China post World War II against the Chinese Nationalists and the Vietnamese Communists against South Vietnam, the latter supported by the US, are examples of LIC changing borders with the acceptance by the international community while the ill-fated Iraqi invasion of Kuwait in 1990 is an example of the international community not accepting conventional military operations aimed at changing borders, leading to the conclusion that what we are used to classifying as LIC/ terrorism/guerrilla operations or an 'adaptation of war' is actually WAR in its most elemental sense and this is likely to increase in scope and use in the foreseeable future as it was in the years before war came to be artificially regulated, and so ending the era of what we today call conventional war fought by dedicated military forces in fairly clearly demarcated battle areas, with fixed and rigid rules imposed by the Western countries for their own advantage. Hence, the trend in warfare appears to be towards what has been labelled Gen 4 warfare.

CHANGING NATURE OF TARGETS

From the air power practioner's point of view, this new type of warfare presents new challenges. In the past, in conventional warfare between nation states, clearly discernible military targets were available. These included massed formations of armour, troop concentrations, vital infrastructure such as airfields, Petrol, Oil and Lubricants (POL) depots and their transportation networks, lines of communication, both road and rail, centres of manufacturing, ports, etc. apart from the seat of the opponent's economic and political power. The problem in earlier times was developing air forces able to effectively address the vast number of potential targets available. There was also a relatively clear demarcation between non-combatants and military forces. It was only in rare cases that non-military targets were attacked by regular military forces and this was ascribed to retaliatory action or other overpowering political direction. Fears of collateral damage were not too great in regular military activities due to the ease in recognising military and non-military targets and a widely accepted demarcation that

What are now faced are widely dispersed bands of personnel who look like the general population and do not usually opt to wear distinct, easily recognisable uniforms, armed with personal weapons, some of which could be quite powerful, and able to mix with the surrounding population due to appearance and cultural similarities.

kept the non-military targets free from military attack in terms of the generally understood and accepted 'rules of war'. With the changing nature of warfare, the earlier targets have vanished overnight. What are now faced are widely dispersed bands of personnel who look like the general population and do not usually opt to wear distinct, easily recognisable uniforms, armed with personal weapons, some of which could be quite powerful, and able to mix with the surrounding population due to appearance and cultural similarities. These bands of armed personnel faced by the nation state do not depend upon the vast infrastructure that regular armies did. Hence, the target list shrinks drastically. This type of warfare has been called LIC as in this type of conflict, the major capital weapons of regular warfare—warships, submarines, main battle tanks, bombers, howitzers, etc—are generally conspicuous by their absence. Regular military forces built for interstate warfare suddenly find themselves at a loss about what and how to target, and how. Weapons designed to take out massed battle tanks are suddenly redundant as there are no tanks on the battlefield. Even the battlefield of old is not there anymore. The irregular forces of LIC-based non-state actors converge rapidly where required, overwhelm their targets, and disperse again to move to their next area of interest. At most, these people may be targeted when they are seen to be converging to take over an area of interest to them. This, however, would require accurate knowledge of their intentions through possibly Human Intelligence (HUMINT), not the easiest thing to obtain when dealing with secretive, well organised, quasi-terrorist organisations. The leadership of such organisations is also very mobile, with protection through dispersal and pre-decided chains of succession. Al Qaeda was based upon a large network of individual small organisations. All of these independent small

organisations were for the most part kept ignorant about each other except where their task required the information, that too on a need to know basis. These independent cells were directed from a distance to carry out supporting activities in pursuit of the overall objective. The matrix organisation-like structure ensured survivability of the overall organisation in case of elimination of any one particular easily identifiable leader. Elimination of Osama bin Laden, the head of Al Qaeda, in a conventional organisation could have been expected to lead to the unravelling of the organisation, however, even after Osama's death, Al Qaeda remains a going concern for all intents and purposes. The same is likely with other similar organisations that are at the centre of conflict in most parts of the world.

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ACCURATE AND RELEVANT INTELLIGENCE

It has been mentioned earlier that good intelligence has been a prerequisite for effective air-to-ground attack. The nature of earlier air attacks, such as during World War II, saw very large numbers of weapons being dropped in the target zone. Of these, the final spread often covered a few square kilometres. Even if the bombers failed to target the intended target accurately for reasons of lack of knowledge of its exact location, the unintended spread of the bombs dropped gave some hope that at least a few bombs would detonate close enough to the intended target to cause damage. Large bomber raids and bombers that carried very large numbers of weapons in effect aimed for a shotgun principle in engaging targets. Guided weapons such as the Paveway LGBs, JDAMs, etc. can typically impact within ten to three metres of their aim point. Such accuracy is useless unless the pilot delivering the weapon knows where the weapon should be delivered for the desired effect. In addition, he must be able to acquire, identify, and track the aim point so as to place the sighting system for the weapon correctly where desired. This high accuracy of modern PGMs makes it imperative that they be aimed at

the correct target. Hence, development of more accurate weapons has led to a complementary requirement for intelligence of a much higher calibre than was the case before. For these weapons to be used effectively, there is need for very accurate and up-to-date intelligence on the location and other parameters of potential targets. In addition, weapon target matching needs to be done to, firstly, match the target characteristics and desired destruction level with the weapons and also, in view of the high cost of such weapons and their support infrastructure, to match the cost and benefit of addressing a particular target. In modern Gen 4 warfare, this intelligence requirement increases even more as it is quite likely that the hostile elements may surround themselves with innocent people by design. The challenge now is to obtain intelligence accurate and up-to-date enough to accurately engage the hostiles while causing minimum, ideally nil, collateral damage. Weapons able to deliver this capability include the US GBU-39 Small Diameter Bomb (SDB) , and laser guided 70mm (2.75 inch) calibre rockets being tested by British Aerospace Systems, to name just two. The most accurate air-to-ground weapons remain LGBs while other bombs exploit the IR, optical, and radar parts of the EM spectrum for guidance. All of these weapons require accurate intelligence on target locations and characteristics. LGBs also require laser illumination of the target for guidance. This illumination could be carried out by an airborne platform or by special forces troops inserted in the area for target designation by the use of small portable laser illuminators. IR, optical and radar-based weapons usually depend only upon their onboard sensors for guidance. In the absence of special forces, other infiltrators could also be employed for laser target designation. The latter may, in some circumstances, be more effective than special forces if they are able to merge with the local population or are drawn from that population itself.

The means of obtaining this intelligence require some thought. Firstly, it could be expected that modern means of intelligence collection through use of satellites, reconnaissance aircraft, Signals Intelligence (SIGINT) and Electronic Intelligence (ELINT) assets would be used. In addition, especially in Gen 4 warfare, the need of HUMINT increases manifold. Despite the modern means of intelligence gathering, the fact that Gen 4

warfare, combatants are trained and equipped to eschew modern weapons and to practise guerrilla type tactics makes HUMINT essential when fighting such opponents. Gen 4 combatants are likely to use non-military technology more than military technology. While not usually possessing high power military grade communication sets, these people could be adept at the use of cellular phones and internet-based communications, including social media sites for effective communication and coordination. This fact, coupled with the diffused nature of the leadership in many Gen 4 warfare organisations, increases the importance of intelligence gathering, moving beyond traditional military arenas of operation to keep a track of what is traditionally civilian technology also. There is no escape from the necessity of obtaining up-to-date and accurate intelligence from all possible means for air power to be utilised effectively.

IMPERATIVES OF ACCURATE ATTACK AND COLLATERAL DAMAGE

Unlike conventional military forces, the new non-state forces have no issue with merging with the local population for camouflage as well as protection. Often, they desire members of the local population to be the target of the opponent's attack in order to harvest the resultant anger against the attacker amongst the local population to bolster their ranks. The willingness of the new non-state forces to mingle with the local population presents great challenges for conventional military forces in dealing with them. Conventional militaries require to ensure that while engaging the non-state armed personnel, they cause no, or at least, minimal collateral damage. This is not easy for military organisations designed, trained and equipped to use the maximum required force to destroy the enemy. There is need for a change in mindset as well as equipment and its utilisation philosophy. Weapons should now be used in carefully controlled situations and utmost care must be taken to ensure that innocent bystanders are not harmed even at the cost of taking casualties. Any casualties caused to innocent bystanders, covered by the term 'collateral damage', by application of the military power of a state's forces operating against non-state forces are usually blown out of proportion as instances of brutality and war crimes and lead to the state forces suffering a major

propaganda loss. Hence, there is great pressure to avoid collateral damage. This can be seen in all regions where conventional military force is being used against new style irregular forces. The imperative to reduce collateral damage has forced all modern militaries that are engaged in such warfare or foresee the need for engaging in such operations in the near future, to induct PGMs. The search for cheap PGMs has led to the new satellite guided bomb, the JADM, as the weapon of choice as it costs appreciably less that the earlier LGBs, etc. Smaller calibre accurate weapons such as the US SDB[25] have been developed to reduce the collateral damage effect in LIC operations. Guided relatively small calibre rockets have also been developed to ensure accurate delivery and just enough warhead effect to destroy the intended target without collateral damage.[26]

COST VS. EFFECTIVENESS OF HIGH END AIR POWER IN LIC

The typical target that the new type of warfare most usually presents is a small group of individuals armed with assault rifles, a few grenades, and, may be, a man portable missile launcher spread over a few tens of square metres. The identity of these people is not usually available. Hence, they could be lowly foot soldiers at the bottom of the non-state militant organisation or even members from amongst its top commanders. Their presence is unlikely to persist for much time as once they have done what they gathered for, they could disperse in small numbers into the surrounding countryside to move towards their next objective. Such fleeting targets require near full time surveillance of the area under consideration with real time monitoring of the myriad sensors to spot, analyse and classify such fleeting targets on priority for appropriate action. This surveillance task itself is prohibitively expensive in terms of equipment and manpower resources. Reducing the sensor-to-shooter time lag has become even more important today with the fleeting nature of the new targets. The solution so far has been to arm the surveillance

25. Kris Osborn, "Air Force Tests Small Diameter Bomb II to Hit Moving Targets", http://defensetech.org/2014/07/16/air-force-tests-small-diameter-bomb-ii-to-hit-moving-targets/. Accessed on November 19, 2014.
26. "Affordable Precision", http://www.raytheon.com/capabilities/products/lgr/. Accessed on November 19, 2014.

RPA with light PGMs such as the US Hellfire missile on the Predator and Reaper RPA. These craft have been used extensively in Afghanistan, Yemen and the Middle East with some success, but notable failures as well, in that innocent people were often attacked. Such errors could be ascribed to errors in the analysis of the imagery data, coupled with faulty HUMINT or Technical Intelligence (TECHINT).

Surprisingly, there have been missions flown by very high end LO aircraft such as the B-2 and F-22 on such LIC operations.[27] Given the total absence of any opposing air power in such scenarios, this defeats understanding. LO aircraft are designed to penetrate contested air space successfully. If there is no opposing air force at all, then their use is overkill by several magnitudes as even unarmed light aircraft could possibly operate in such air space unmolested. These LO aircraft usually use PGMs as their weapon of choice. Given the cost per flight hour of such LO aircraft and the high cost of especially Western PGMs, the cost–benefit ratio of spending several million dollars to kill two or a dozen lowly armed guerrillas needs some serious thought. The other aircraft currently in use against LIC type forces in Iraq and Syria, which were earlier used in Libya, for instance, include the Eurofighter Typhoon and French Rafale. These Gen 4+ aircraft also carry a high cost per flight hour; though admittedly much lower than that of the US LO fighters. The PGM weapons used by both the Gen 4+ and Gen 5 aircraft still cost about the same in both cases. These fighters also deliver a very high cost per mission. The high cost is easily justifiable if the mission targets the top leadership of the LIC force and delivers benefits out of proportion to the actual casualties caused on the ground. However, given the difficulty in determining the location and, at times, even the identity of this leadership, this is like looking for a needle in a haystack.

The cost of using this high end equipment designed and built for a very different scenario in this manner appears to be a waste that could pull the operating country into the dark well of economic downfall. The most suitable

27. Colin Clark, "F-22s Used In Syria Strikes; Right Force, Right Time, Say Analysts", http://breakingdefense.com/2014/09/f-22s-used-in-syria-strikes-right-force-right-time-say-analysts/. Accessed on November 19, 2014.

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airborne platform for such LIC dominated scenarios is, of course, the attack helicopter. This machine carries awesome firepower, is slow and close enough to the targets for better recognition, has high persistence as compared to fixed wing aircraft, can deploy guided munitions to avoid collateral damage and is mobile enough to redeploy rapidly in response to dynamic situations. The helicopter is, however, vulnerable to even small arms fire and, thus, especially in its attack helicopter *avatar*, comes suitably equipped with armour plating to protect crucial parts of its airframe and engine(s). Other aircraft suitable for such missions date back to Gen 3 fighters such as the US A-10 "Thunderbolt" and Soviet era Su-25 "Frogfoot". Both these aircraft were designed as Close Air Support (CAS) aircraft and were intended to be operated in the tactical battle area in support of friendly forces against enemy surface forces. Hence, these aircraft were designed to be able to deliver adequate firepower accurately and incorporated extensive self-defence hardening in terms of armour plating and redundant systems to make them very difficult to destroy. In the US operations in Kuwait and Iraq as part of the Gulf War of 1991, 70 of the 144 A-10 aircraft deployed for operations in the area suffered damage. However, by the end of the war, 14 of the damaged aircraft had already been repaired and returned to service, indicating the high ability of these CAS designs to take punishment and survive. Such specialist CAS aircraft cost much less than more advanced LO aircraft to develop and build and are, hence, more affordable for such missions. The close proximity of their operation to the targets enables some reduction in PGM usage and, hence, costs. Most trainer and old generation light fighter aircraft could be modified into suitable and effective platforms for use in this scenario at a fraction of the cost of a single Gen 4+ or Gen 5 aircraft. The use of Gen 4+ and / or Gen 5 aircraft to undertake LIC operations in which expensive aircraft use costly PGMs to take out individual fighters of the non-state forces appears to be

a sure way to economic doom. Intelligence agencies require a revamp to deliver better actionable intelligence and targets. Targeting individuals can be justified if these individuals are positively identified as the top leadership of the non-state organisation in a situation that such attacks will yield commensurate benefits.

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The demise of old target systems of conventional war extends to attacks on oil refineries and other oil facilities. In the conventional warfare of old, nation states' economies depended upon availability of POL products for the country to function as well as for effective military operations. Thus, destruction of oil facilities was deemed to have an effect on the outcome of a war. This effect would not in most cases be immediate as any sensible opponent would have stockpiled reserves for several days or even weeks of operation. However, ultimately, destruction of oil facilities would be expected to lead to a favourable outcome due to fuel starvation caused by disruption of oil supplies and exhaustion of strategic and tactical reserves. In the case of non-state opponents, oil facilities become a much less effective target. By definition these non-state forces are independent of the trappings of nation states and do not rely upon mechanised armed forces. Hence, the relevance of attacking oil facilities in such operations against non-state opponents is greatly reduced, even to the point of futility. Exceptions may exist like in the current case of the IS which is using oil from captured oil fields to generate funds for its operations.[28] In this unique case, some attacks on oil facilities may yield medium term results through reducing the resource flow of the IS. Thus, this brings out the importance of a careful analysis of the opponent to identify suitable targets for immediate / short-term, medium-term as well as long-term effects.

28. Eline Gordts, "How ISIS Uses Oil To Fund Terror", http://www.huffingtonpost.com/2014/09/27/isis-oil_n_5877008.html. Accessed on November 19, 2014.

ANALYSIS

The changing nature of war requires military forces to carry out a detailed and effective analysis of their environment in the medium and long-terms to determine the nature of capabilities required to be inducted. Failure to do so could result in the situation that the US and most of the West find themselves in today. These countries are saddled with very powerful and effective air power assets that cost as much as many smaller countries' Gross Domestic Product (GDP) but impose penalties of forcing operation of very expensive missions which are clearly not sustainable in the long run. These expensive missions are also not effective in the new environment as their high cost would suggest. The West often justifies the use of its most advanced technology in this unsustainable manner by holding that these costs are preferable to loss of lives of their troops involved in ground operations. The aim seems to be to fight and try to win "bloodless wars" at least in terms of their own casualties. It needs to be emphasised here that wars cannot be fought and won without casualties. If there is a will to fight, this perforce has to be accompanied by the willingness to take reasonable casualties. Political and military planners require to ensure that they are not seduced by the glitter of 'gold plated' high end weapons programmes to an extent that the other end of the spectrum is ignored. The military forces of a nation should be configured to deliver the capabilities actually required and not capabilities that belong to a different era or to an out of vogue type of operation.

Ideally, both ends of the spectrum of warfare as we know it should be covered. There should be viable high end, medium end and low end capabilities planned for, and inducted, with relevant doctrines, tactics, etc. also in place. This catering for both the high as well as low end of the possible spectrum of conflict could be termed as development of 'balanced military forces'.

It is true that there is a strong line of thinking that military forces require to put in place capabilities that assist in effective and efficient discharge of their tasks and these military forces should not bother about costs, etc. However, it is a truism that all countries, even the superpowers, are facing economic difficulties. In such a situation, it behoves military leaders to also

give some thought towards the cost of the capabilities they desire to put in place. Here it should be borne in mind that there is a tendency in military forces all over the world to opt for the very best equipment in preference to equipment that could be less advanced but can do the job at hand. It should be kept in mind that "the excellent is the sworn enemy of the good enough".

CONCLUSION

Aircraft technology has developed at a rapid pace in the past century. The advances in technology have delivered near science fiction analogues into the hands of war-fighters; near invisible combat machines, precise "smart" weapons, a near ubiquitous surveillance capability, robotics on the battlefield, etc. One of the most interesting of these is the advent of LO technology and PGMs. In conventional warfare for which these LO aircraft were designed, they can be game changers. LO technologies as well as PGMs carry a very high cost of acquisition as well as operation. The nature of war has also changed to become more LIC in nature, with dispersed lightly armed irregular opposing forces operating at the lower levels of technology. The utilisation of advanced LO equipment against LIC opponents has been carried out in the recent past but in view of the costs involved, this appears unsustainable. Targeting of individual opposing fighters with expensive weapons released from expensive to own as well as operate aircraft seems a sure way to bankruptcy, given that killing individuals at the rough cost of several thousand dollars per head when there are tens of thousands to kill, would reduce even the US or China to penury in a few months. Military aviation requires retaining the earlier capabilities of the Gen 3 era of specialist CAS aircraft and attack helicopters for effective operations against LIC opponents, given the current rise of this kind of warfare. These issues have a bearing on the force structure planning of all modern air forces and ignoring them would not be advisable. It should also be borne in mind that in any conflict, both sides require to be ready to accept casualties. Military planners, in an era of resource shortages, will, in all probability, increasingly require paying heed to the cost of their equipment as well as its effectiveness.