FROM UNGUIDED BOMBS TO PRECISION WEAPONS

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> Aircraft enable us *to jump over* the army which shields the enemy government, industry, and people, and *so strike direct and immediately at the seat of the opposing will and policy*.
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> —Captain B. H. Liddell Hart, British Army.

INTRODUCTION

Air power, from its inception, has enhanced the war-waging potential of a nation by taking the war into the hinterland of an adversary. The characteristics of reach and flexibility of air power impose additional demands on the effort to defend the vast number of vital points. The vital points which were invulnerable earlier, are now exposed to the combat prowess of an adversary. As technological progress was made in the aviation industry, the weapon industry has also witnessed corresponding but exponential growth in the field of aerial weapons. Thus, it has endorsed the lethality and effectiveness of air power, if utilised in an intelligent manner. In the Indian context, in the conflict in the high mountains of Kargil, the nation witnessed the accuracy and destructiveness of the aerial bombardment of enemy positions utilising precision weapons: the Laser

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Guided Bombs (LGBs) utilising the Laser Designated Pods (LDPs) on the Mirage-2000 aircraft. Prior to this, the world was witness to the high-tech precision weapons in the arsenal of the Allied forces during the Gulf War. The development of these precision weapons had started well before the computer revolution of the 1980s and the precision achieved during the Desert Storm campaign was an evolution in the annals of aerial warfare and not a revolution for the world to see. This is perhaps one evolution that continues till date and is likely to continue as long as man continues to utilise air power to conduct warfare.

The development and deployment of Precision Guided Munitions (PGMs) have changed the approach to warfare as it gives air power the capability to engage and destroy the enemy utilising conventional munitions with precise accuracy, limiting collateral damage and thereby economising on both time and effort. Besides enabling pinpoint accuracy without having to cater for external factors, it gives the pilots and planners a high level of assurance of mission accomplishment, target engagement and its destruction/neutralisation. Also, as the damage caused by the weapons decreases with an increase in distance as per the inverse cube law, an increase in accuracy of delivery would ensure that the target can be destroyed with either a fewer number of bombs or with a smaller calibre of bombs. This phenomenal jump in capability compared to unguided bombs reduces the Over the Target Requirement (OTR) in terms of the number of weapons for planners and increases the capability of air power to engage more targets with the same number of aircraft. This would also entail putting fewer aircraft at risk over a planned target for engagement. Air power always had the ability to engage any target, however, it was the capability of the weapons (in terms of numbers required, accuracy of delivery,

effort available, etc.) which was the limiting factor for the planners. Precision munitions, in one master stroke, negated all this and planners now have the ability to plan engagement of any target any time during the war, with assured destruction to achieve the desired effects.

A BRIEF HISTORY OF THE DEVELOPMENT OF AERIAL WEAPONS

Engaging a target from the air is a dream that many theorists wanted to realise even before the Wright brothers had taken to the air in their heavier-than-air vehicle in 1903. They, perhaps, were unaware of the various factors that affect the accuracy of a munition released from the air. These factors led to inaccuracies which increase exponentially compared to an increase in release distance and height. The Desired Mean Point of Impact (DMPI) to be engaged as desired by the pilot could be engaged from the infinite number of release points which depended on all or some of these factors which included aircraft speed, height, wind speed and many more. This led to the requirement of precision bombing wherein one could engage the planned DMPI each time without having to constantly worry about, if not all, at least of some, of these factors. This desire for perfect accuracy led to the development of precision weapons.

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The massive bombing raids of World War II required a large number of assets in terms of bombers and escort aircraft and the outcome was a large amount of collateral damage with the target not being destroyed on many occasions. The actual target in many cases could have been engaged with a lot less ordnance had there been a more accurate sighting technique. For example, in 1944, in the Pacific theatre, 47 B-29 aircraft dropped 376 bombs over the Yawata Steel Works with the planned DMPI of the coke house of the steelworks with the most accurately dropped bomb falling on the steelworks

3,700 ft from the planned DMPI.[1] As per the available data, in World War II, it required a wave of 108 B-17 bombers dropping 648 bombs to achieve two hits in a 400×500 ft German power plant.[2] And to hit a 60×100 ft target with a 90 per cent probability would have required approximately 9,000 bombs in that era. This number had reduced to approximately 1,100 during the Korean War and was approximately 175 during the Vietnam War. The Circular Error Probable (CEP) achieved during World War II was 3,300 ft;[3] and this perhaps was the driving force behind the development of more accurately delivered munitions.

The Germans were the first to use a radio-guided glide bomb, the Fritz X, to sink the Italian battleship *Roma* during World War II. The Japanese *kamikaze* attackers, if considered as human-guided munitions, were perhaps some of the most successful munitions during World War II, with 14 per cent scoring a hit on the ship.[4] Their success caused the Allies to change their naval plans even though they were very few in numbers as they were able to influence battle outcomes out of proportion to their numbers and strength. The United States Army Air Force (USAAF) developed and deployed the VB-1 Azon with an autonomous radar seeker system while the US Navy deployed the ASM-N-2 Bat during World War II.

World War II witnessed the application of air power in tactical, operational and strategic campaigns during the war. The concept of strategic bombing of the enemy's war-waging capacity and population centres to affect its capacity and will to fight did not produce the results as envisaged by the great thinkers and strategists of air power (Mitchell, 1925; Douhet, 1921). During the war, both sides had planned operations to destroy the will of the people by bombing large population centres and the ability to wage war by targeting key infrastructure and industries, but neither side could achieve the desired result, i.e., a swift victory. It was probably due to the one fundamental flaw in the capability of air power during those days: precision. The lessons of World

1. Richard P. Hallion, "Precision Guided Munitions and The New Era of Warfare", http://www.fas.org/man/dod-101/sys/smart/docs/paper53.htm. Accessed on December 1, 2022.
2. Ibid.
3. https://www.encyclopedia.com/history/encyclopedias-almanacs-transcripts-and-maps/precision-guided-munitions. Accessed on December 1, 2022.
4. Ibid.

War II almost destroyed the concept that air power could be decisive in turning the tide of war in one's favour. The development of nuclear weapons led to an entirely different era of strategic bombing wherein precision did not have any role and the development of PGMs, thus, slowed down and was relegated to development for tactical or operational tasks.

The war in the Korean Peninsula was a war that saw the air space being utilised by the US forces in support of the ground forces to slow down the advancing North Korean Armies. The North Koreans had a poor air power capability presenting little opposition and the good weather and plentiful targets were a favourable ground for interdiction of enemy troops by air. The US utilised the VB-3 RAZON and TARZON (TAll Boy RAZON) optically guided bombs developed during World War II. The achieved CEP was 40ft[5] with only 13 per cent of the bombs achieving a direct hit. Though the number of direct hits was low, the number of targets destroyed was more as compared to that achieved by unguided bombs. The lessons from the Korean War were almost similar to those from World War II—good weather and air superiority were essential components for achieving good and effective bombing results. This led to limited research in the guided bomb programmes in the US till the need for more accuracy was felt during the Vietnam War.

Despite having been developed and deployed in some numbers in World War II and utilised in some numbers during the Korean War, guided munitions came of age during the Vietnam War. On April 27, 1972, the infamous Thanh Hoa bridge was struck by eight LGBs which destroyed one-half of the bridge.[6] This bridge was revisited by the US Navy aircraft carrying 12 LGBs to send the bridge to the bottom of the river. What made this raid a spectacular event was that before this, thousands of sorties had been flown against this bridge target between 1965 to 1972 but the poor accuracy achieved with unguided bombs had caused only minor damage to the bridge

5. "An Interim Report on Air Proving Ground and Other Experimental Activities in Support of Korean Operations", September 1951, AFHRA, Maxwell AFB, AL (call no. K240.04B), p. 13.
6. https://en.wikipedia.org/wiki/Thanh_H%C3%B3a_Bridge#cite_ref-22. Accessed on December 12, 2022.

It was in the 1980s that great strides were made in laser guidance for PGMs as well as Imaging Infra-Red (IIR) guidance which had been developed as an alternative to laser guidance for PGMs. PGMs had come of age and in the last four decades had proved to be highly successful and accurate.

which was repaired expeditiously by the North Vietnamese.[7] For the first time, the bridge had been targeted with pinpoint accuracy ensuring its collapse and total annihilation. This was a watershed event for the utilisation of PGMs in the Vietnam War. As the war progressed, more and more missions utilised PGMs for engaging targets, and the US Navy and Air Force gained experience and developed tactics to utilise these PGMs. Development of these weapons was also accelerated as the need to utilise these weapons against a larger variety of targets increased with more than 900 being produced every month. By the end of 1973, 50 per cent of the PGMs utilised were direct hits with a CEP of 23 ft while the unguided bombs achieved only 5.5 per cent of direct hits with a CEP of more than 300 ft.[8]

During the 18 days of the Arab–Israel War of 1973, the Israelis utilised PGMs to achieve 96 per cent direct hits on the Arab tanks and bridges.[9] Though the numbers used were small, the effectiveness of the PGMs was decisive in halting the Arab armour advance. In 1986, the US utilised PGMs to engage terrorist organisations at night inside Libya. The attacks were achieved with pinpoint accuracy and with minimum collateral damage. It was in the 1980s that great strides were made in laser guidance for PGMs as well as Imaging Infra-Red (IIR) guidance which had been developed as an alternative to laser guidance for PGMs. PGMs had come of age and in the last four decades had proved to be highly successful and accurate.

The invasion of Kuwait by Iraq and the Allied offensive against it in Operation Desert Storm was the culmination of years of dilly-dallied

7. Paul G. Gillespie, *Weapons of Choice: The Development of Precision Guided Munitions* (Tuscaloosa, AL: University of Alabama Press, 2006).
8. Donald I. Blackwelder, *The Long Road to Desert Storm and Beyond: The Development of Precision Guide Bombs* (Air University Press, 1992), p. 27.
9. Ibid., p. 32.

development of PGMs. The war was projected live across the world and the spectators got to see through the viewing lenses of the PGMs targets all across the battlefield being engaged with pinpoint accuracy. The operation once again established the primacy of PGMs for engaging targets without causing excessive collateral damage. Though only 8 per cent of the ordnance utilised comprised PGMs, they achieved a nearly 100 per cent success rate and more than 90 per cent of direct hits with a CEP of less than 30 ft. Compared to the tens of thousands of civilians killed in the bombing raids of World War II, only 23 civilians were killed in the first 36 hours of Operation Desert Storm.[10]

The IAF was formally raised on October 8, 1932, as a separate air force by a legislative Act in spite of opposition from the RAF pilots but it was not until April 1, 1933, when No 1 Squadron (Sqn) was formed with four Wapiti aircraft that the IAF could take to the skies.

IAF AND ITS CAMPAIGNS

During the early years of aviation, air power was first utilised in the Indian subcontinent in 1916-19 against the belligerent tribal armies of the Emir of Afghanistan. Called air policing in those days, air power was used for armed reconnaissance (recce) and offensive strikes in support of the ground forces. Though the Indian Air Force (IAF) was yet to be created, the Royal Air Force (RAF) squadrons positioned in the North-Western Frontier Province (NWFP) carried out attacks against the tribal positions in support of the ground forces. Between the period of March-May 1925, the RAF squadrons dropped more than 150 tonnes of bombs on the Afridi and Mahsud tribes as punitive action against them.[11]

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10. Ibid., p. 39.
11. Arjun Subramaniam, *India's Wars: A Military History 1947-1971* (Noida: HarperCollins Publishers), p. 88.

aircraft that the IAF could take to the skies. The first two IAF squadrons were positioned in the NWFP to aid the army in the operations against the tribals. The IAF attacked targets nominated by the land forces utilising 20-pound (lb) bombs and, on some occasions, 112 lb and 250 lb bombs.[12] The inaccuracies in aerial bombing and strafing required advance notice to the friendly population not to use the area where the action was planned and any collateral damage had to be accepted as part of the campaign.

It was during World War II that the IAF was utilised extensively on the Burma Front not only for armed reconnaissance (recce) but in support of the ground forces as well. The pilots carried out dive bombings and strafing utilising aircraft integral guns on targets. Though the IAF Lysander aircraft were not as advanced or as capable as the Japanese aircraft in the sector, it was the ingenuity and skill of the IAF pilots that ensured that the missions were a success, with minimal losses.[13] No 1 Sqn operating in support of the 14th Army on the Burma Front was instrumental in stalling the Japanese advance on Imphal. Spotted first by squadron Leader Arjan Singh, Commanding Officer No 1 Sqn, the complete squadron was scrambled to thwart the advance of the Japanese armour and troops towards Imphal.[14] By the end of World War II, the IAF had carried out a large number of roles in support of the ground forces but very limited offensive bombings.

Independence led to the partition of the country and the division of assets between the Pakistan Air Force (PAF) and the IAF. The first war of 1947-48 saw the IAF utilising its aircraft in support of the army and no action was taken against any PAF airfields. PAF aircraft also did not provide any opposition to the IAF aircraft in the air space over Jammu and Kashmir, and the IAF was able to operate in an environment of total air supremacy. It was the joint army-IAF operations which finally stopped the raiding tribesmen in their tracks and forced them to retreat till Uri.[15] The IAF, in support of the

12. Air Vice Marshal AK Tiwary, VSM, *Indian Air Force in Wars* (New Delhi: Lancer Publishers), p. 8.
13. Ibid., p. 20.
14. Ibid., p. 29.
15. https://web.archive.org/web/20030803140837/http://www.bharat-rakshak.com/IAF/History/1948War/Overview.html. Accessed on December 10, 2022.

ground forces, utilised integral guns and rockets for attacking the targets in an uncontested air space. The results were there for all to see and the close support provided by the IAF was instrumental in turning the tide in the first war of independent India.

In 1961, in Operation Vijay for the liberation of Goa, Daman and Diu, the IAF once again operated in a total air supremacy scenario where no opposition was faced and the pilots were free to carry out attacks against land targets and in support of their own ground forces without the fear of being engaged by enemy aircraft. In Goa, the IAF carried out attacks against the airport and communication centres and in support of the army moving in. Twelve Canberra aircraft dropped 63,000 lb of bombs on the airfield to put the runway out of action. This was followed up by another 8-aircraft raid on the same airfield.[16] Buildings and structures were left untouched and even with such a large amount of ordnance utilised against the airfield, the Portuguese were able to hastily repair the runway to utilise it to escape under the cover of the night. Against the wireless station at Bambolin which was the backbone of the Portuguese communication at that time, six Hunters were required to put it out of action using a mix of guns and rocket weapon load. In addition, in the Daman sector, the IAF flew 14 sorties against gun targets harassing these gun positions throughout the day. In the Diu sector, the IAF had to fly 35 sorties against the runway and defences at Diu to cripple them before the ground forces moved in across the creek to complete the takeover of the island.[17]

The war of 1965 was the first war in which the IAF operated in contested air space not only in support of the ground forces but also for offensive missions. However, in the Lahore and Khem Karan sectors (Operation Stalemate) and in the Chamb and Akhnur sectors (Operation Grand Slam) both the IAF and PAF closely contested the air battle to support the ground forces. IAF strikes over Sargodha with bombs were intercepted. In the planned five waves of attacks, three waves were by Mystere aircraft and two by Hunter aircraft.

16. https://web.archive.org/web/20031005110857/http://www.bharat-rakshak.com/IAF/History/1960s/Goa01.html. Accessed on December 12, 2022.
17. Subramaniam, n. 11, p. 191.

The damage caused on the ground was minimal: a number of aircraft (Sabres and Starfighters) were hit and one of them was burning furiously. In this raid of five waves over Sargodha, the IAF lost nine aircraft.[18] The IAF had a little better result in the eastern sector where the raids on Chittagong, and Kurmitola caused damage to the operating surfaces in every wave of the raid.[19] A study of the claims for targets on the ground during the 1965 Indo-Pak War suggests that the IAF was able to damage only 18 aircraft on the ground in the Pakistani airfields.[20]

It was the 1971 War of Liberation of Bangladesh that was the golden chapter of the IAF history. The IAF not only took on its conventional roles of offensive and defensive air campaigns but also had a large per centage of planned sorties in support of the Indian Army. All modes of attacks were utilised by IAF aircraft in the eastern sector, with all available types of armament and weapons. Though the war started with the contest for air space over East Pakistan (now Bangladesh) between the PAF and IAF, the IAF, with properly planned campaigns, was able to achieve total air superiority in the eastern sector within the first few days of the war. The error in bombings achieved by the end of the war in the eastern sector was approximately 30m in line and range, while for rockets, it was as low as 10m.

These errors of 10m and 30m may not seem much, but for point targets like bunkers and dugouts, they were errors that could lead to a mission not accomplished. This was what was seen in the initial days of the next conflict by the IAF planners in the icy heights of Kargil in 1999. The initial deployment of MiG-21, 23, and 27 aircraft for low-level strikes led to aircraft losses and the IAF had to change track to high level strikes. The steep slopes, pinpoint targets (dugouts, pillboxes and bunkers) and aircraft operating from high altitudes such that some weapons were not charted for release from those heights, led to the IAF resorting to precision bombing. The success of the

18. https://web.archive.org/web/20030803140837/http://www.bharat-rakshak.com/IAF/History/1965War/Chapter4.html. Accessed on December 10, 2022.
19. https://web.archive.org/web/20030802032011/http://www.bharat-rakshak.com/IAF/History/1965War/Chapter12.html. Accessed on December 10, 2022.
20. https://web.archive.org/web/20030802032007/http://www.bharat-rakshak.com/IAF/History/1965War/Chapter10.html. Accessed on December 10, 2022.

subsequent air strikes utilising the M-2000 aircraft turned the tide of the operation in favour of the Indian forces. Though a very limited number of LGBs were utilised (eight from M-2000 aircraft and one from Jaguar aircraft[21]) the era of precision bombing had arrived in the IAF. The lessons from the Gulf War of 1991 and the Kargil War (Operation Safed Sagar) were clear for the air power planners: the IAF could no longer rely only on unguided bombs and the need for precision weapons for future operations was critical to ensure success.

CONCEPT OF TARGETING

Prior to working out the way forward, it would be prudent to analyse the way the concept of targeting has evolved. Based on the stated military strategies for war which are culled out of the national security strategy, the services work out the joint strategy to meet the overall aim. When we talk of ends, ways and means to achieve the overall objectives, targeting is one of the means to achieve the same. Hence, in any war, the concept of targeting by each service has to be well thought out to keep the overall war effort focussed in the right direction.

Choice of Targets: The effects-based approach has been professed for a long time now. Based on the desired effects, the targets have to be chosen diligently to achieve the objectives in the most efficient manner. This is the most arduous task, as the success of the entire strategy or objective hinges on this aspect. We use the term surgical operations quite often. In a true sense, the entire concept of targeting and the process of choosing targets based on the desired effects can be encompassed under this head. A surgeon, prior to undertaking surgery, does a complete clinical scan, identifies the organ/problem area to be tackled, chooses the right mode of surgery and the tools required, and performs the operation, thereby achieving the desired results. Similarly, based on the various inputs by Intelligence, Surveillance, Reconnaissance (ISR), the adversary is analysed to identify the targets to be

21. https://web.archive.org/web/20030810210442/http://www.bharat-rakshak.com/IAF/History/Kargil/PCamp.html. Accessed on December 10, 2022.

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tackled based on the desired effects/ results. The weapons are the tools to address these targets. The choice of weapon would further depend on the prevailing environment in the target area and the platforms to be utilised.

Nature of Warfare: Classically, the changing nature of war [fourth generation warfare, irregular warfare, hybrid warfare, anti-terrorism operations, Low-Intensity Conflict Operations (LICOs)] requires the IAF to reequip, reassess its plans and, accordingly, plan its response against the expected threats in the coming years. The close scrutiny of media reports (both national and international) of all operations carried out has caused the campaign and mission planners to ensure proper target identification, correct target-to-weapon matching and ensuring no collateral damage during operations.

A closer look at the ongoing Russia-Ukraine conflict is necessitated at this juncture to identify the changing nature of warfare. Despite the overwhelming capability and force size of its forces, Russia remained unable to gain air superiority due to a number of reasons. It couldn't concentrate the impacts of the missile and air strikes on vital critical Command and Control (C2) nodes and failed to merge non-kinetic effects with kinetic strikes. Air power in the Ukraine War signifies the shifting trends in air warfare. The changing landscape in air warfare highlights the ascendance of denial strategies that have two key dimensions: the offensive one represented by rockets, missile threats, artillery, and drones; and the defensive one epitomised by surface-to-air systems. The arch drivers of this change include the spread of highly mobile and well-integrated Surface-to-Air Missile (SAM) systems, open-source intelligence, and drones. Innovative use of low-cost military and commercial networks of the unmanned air system in UAV-integrated missions was the most compelling factor, as it supplemented and

propelled the intelligence, surveillance, and reconnaissance to the unit level, streamlining Ukrainian military planning, kinetic strikes, and troop movements.[22]

There are questions being raised on the employment and effectiveness of air power in the way we have been talking about it classically. Before anyone arrives at conclusions on the subject, it needs to be analysed whether the military strategy was well thought out? Are the aims and objectives clearly spelt out? Now match the application of air power: was it in sync with these or not? Why talk only of air power—application of the entire military power of Russia is under question. Tacit support by the West is also helping Ukraine sustain itself despite the overwhelming prowess of Russia. Another major issue that needs to be kept in focus by glancing over the ongoing conflicts is the ability to define the conflict termination criteria. Most of the time, it is noticed that military action starts in full vigour, causing destruction, but thereafter the end becomes blurred. This analysis is a different subject altogether, but it needs to be seen from the right perspective before we arrive at the future requirement of weapons. However, what comes out loud and clear is that conflicts may not end in the crisp timeframe as desired, hence, there is a necessity to cater for the weapon arsenal accordingly.

Since air power has the ability to engage targets simultaneously at both operational and strategic depths, the IAF requires a mix of precision and conventional weapons that can engage the entire spectrum of targets. The type of weapon would be dictated by the type of target, its characteristics and the depth at which it lies.

WAY FORWARD

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22. https://www.paradigmshift.com.pk/air-power-ukraine-war/

and the depth at which it lies. Any critical target or a centre of gravity of the enemy would be provided with Air Defence (AD) cover and the more critical the target, the more heavily defended it would be. All these factors require that the IAF equip itself with a variety of air-to-surface weapons with varying ranges so as to be able to engage a number and varied types of targets. The cost of these weapon systems is prohibitive and, therefore, the need of the hour is to develop in-house capability for manufacturing the requisite weapons.

Contested air space in future conflicts would also lead to the need for longer ranges for weapons and with a lesser requirement for the 'man in the loop' arrangement post-launch. Also, time-critical targets would require weapons to reach their targets quickly and accurately, thereby surprising the enemy and engaging the target before the enemy can react and redeploy its assets. Smart weapons provide the accuracy one desires. However, their cost restricts the quantity that can be procured. Present generation aircraft, with accurate navigation and weapon aiming computers have improved weapon delivery accuracy considerably. Hence, unguided bombs and other unguided air-to-ground weapons delivered accurately would remain the backbone of any offensive action, including that in support of own ground forces. However, the need for standoff weapons with precision capability in all campaigns has to be catered for. Therefore, the IAF not only requires to balance the unguided to smart weapon ratios but also needs to develop a strategy for the purchase of weapons that will ensure a healthy balance of the range, speed and type of warhead/seeker of the weapons as per its operational philosophy.

Emerging technologies in the field of drones are proliferating in a big way. Keeping pace with these, the IAF has also embarked on the acquisition of swarm drones. Weapons delivered from conventional Remotely Piloted Aircraft (RPAs) are also on the agenda and are being pursued vigorously. Range Extension Kits (REKs), are cheap solutions to give unguided bombs the extended range as well as precision capability. Indian industry has already taken a leap in all these areas to meet our requirements.

CONCLUSION

The number of conflicts is on the rise and the nature of warfare is constantly evolving. Weapon technology and its application is also under constant transformation to keep pace with the requirements. The IAF has procured and deployed precision weapons since the late 1990s and their requirements is only increasing as per plans of our future operations. Impetus has been given to long standoff ranges in all the procurements to ensure success as well as survivability in a contested air space. However, considering the financial implications, and the prolonged conflicts that we are witnessing these days, it will not be possible for any air force and the IAF, in particular, to hold only smart weapons in its inventory. A healthy mix of smart weapons with varied ranges, swarm drones and conventional drones with the capability to deliver weapons, as well as unguided bombs, would be necessary to fight the next war/campaign.