PATHFINDER

COLLECTION - VOLUME 10

Edited by Sanu Kainikara

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Foreword

The *Pathfinder* was first published by the Air Power Development Centre in June 2004 and continued uninterrupted until June 2020. Each issue provided a brief, easily digestible review of a relevant air power concept or reflection on history, selected from submissions received by the Centre. This tenth collection of *Pathfinder* articles maintains this tradition, covering a broad range of topics from a diverse group of authors. However, this tenth collection will also be the last produced by the Air Power Development Centre in both of their current forms.

From 2021, *Pathfinder* will continue under the stewardship of History and Heritage Branch. The focus of these *Pathfinder* articles will be, unsurprisingly, more historically focused. Meanwhile, the Air Power Development Centre itself will cease to exist on 2 December, 2020. By the time this tenth issue hits the streets, it will have been replaced by the Air and Space Power Centre, whose focus will cover both domains with a view to their future concepts. Alongside that rebirth, it will launch a new, online digital publication: the *Air/Space* blog. *Air/Space* will provide scope for all our people to submit short pieces on air and space power issues and ideas; pieces on which others can comment and discussion and debate ensue.

I look forward to the same level of high quality submissions that characterised the very best of the *Pathfinder* articles becoming the benchmark for the future of *Air/Space* and the new Centre.

GPCAPT Jason Begley
Director APDC
November 2020

The Air Power Development Centre

The Air Power Development Centre, initially the Air Power Studies Centre, was established by the RAAF in August 1989, at the direction of the Chief of Air Force. Its function is to promote a greater understanding of the proper application of air and space power within the Australian Defence Force and in the wider community. This is being achieved through a variety of methods, including development and revision of indigenous doctrine, the incorporation of that doctrine into all levels of RAAF training, and increasing the level of air and space power awareness across the broadest possible spectrum.

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Air Power Theory & Strategy

The Air Power Journey Part I: From a Secondary to Ubiquitous Capability (#325)

Key Points

- *In the inter-war years, the RAF as the first independent air force embraced the fundamentals of air warfare.*
- *During World War II, the air domain assumed a status of its own, first in Europea and subsequently in the Pacific.*
- *It was only at the end of World War II that a proper understanding of the concept of securing control of the air in order to ensure the unrestricted use of the air domain matured.*

At the end of World War I, air power analysts believed that the psychological impact of aerial bombing would far outweigh the physical damage that it caused. This theory was developed because the physical effect of aerial bombardment was relatively slight compared to the perceived psychological effect that it caused, especially on the civilian population of the adversary country. In the inter-war years, air power evolved in two distinct ways—spearheaded by Germany and Britain. The commonality between the two was that there developed a clear relationship between doctrine and the practical application of air power.

In a broad way it could be surmised that the Royal Air Force (RAF), formed as the first independent air force, adapted the developing and infant doctrine of air warfare to ensure that its independent status was assured. Lord Trenchard, who earned the sobriquet of 'Father of the Royal Air Force', did more than any other single person to steer the independent Service to embrace the fundamentals of air warfare: the ability to control the air, strike targets at will to create the necessary effect, collect intelligence and carryout surveillance and reconnaissance, and provide air mobility. He was also irrevocably committed to the concept of offensive action and also emphasised the need to concentrate the main offensive against the vital

centres of the enemy. Air superiority was a critical element in achieving this objective.

Germany on the other hand had moved in a slightly different direction. The Treaty of Versailles and its protocols had eliminated the German Air Force and its supporting aviation industry. It took a great deal of subterfuge and the Nazi Party led by Hitler coming to power in 1933 for the German nation to announce the creation of the Luftwaffe in 1935. The Luftwaffe developed three primary missions—to combat enemy air forces, to support surface warfare and to disrupt enemy's logistic supplies to the front line. Conspicuous in its absence was any reference to Douhet's theories of strategic bombing since his works started to be translated into German only after 1935. However, in common with the doctrine of the RAF, the Luftwaffe also emphasised attack, or offensive action, as the principle to ensure dominance over the adversary.

At the outbreak of World War II, the two air forces that would dominate the early years of the conflict had individual concepts of operations based on doctrines that were fundamentally different to each other. However, offensive action was the basis for both air forces' concepts of operations although neither of them fully understood the resource requirements to sustain offensive action and the heavy attrition that offensive actions entailed. Air superiority, although considered an important element in the application of air power, was considered an elusive goal that depended on a number of extraneous factors, and therefore difficult to achieve.

There is no doubt that air power was a secondary capability during World War I. However, in World War II it dominated the fighting in most theatres. The concept of blitzkrieg, where tactical air squadrons swept ahead of the German armour thrusts into Poland, France and then Russia came as a shock to the land-centric operational concepts of the large armies. By destroying the opposing air forces (the *Luftwaffe* destroyed 1,811 Soviet aircraft within 24 hours), the German forces ensured unfettered air superiority and demonstrated the need to

maintain control of the air. Towards the end of the War, the roles were reversed, but the cardinal principle remained the same.

Similarly, interdiction played a major role in determining the outcome of fierce land battles. It was not difficult for the planners and commanders to understand that control of the air was a prerequisite for the application of force, whether from the air or form the surface. Likewise, air power became the key to the outcome of naval encounters, with the command of the sea becoming dependent on control of the air. The famous Battle of Midway being the classic example of air power determining the outcome of what was essentially a naval battle.

As World War II progressed, the air domain assumed a status of its own, first in the European and subsequently in the Pacific theatre of operations. Two campaigns, primarily fought through the employment of air power, made it impossible for any strategic thinker to ignore the air dimension anymore—the Battle of Britain and the Bomber Offensive, both having been repeatedly and comprehensively analysed since 1945.

In the Battle of Britain, fought in the early stages of World War II, the failure of the Luftwaffe to gain air superiority over the English Channel and Britain has been rightly attributed to the change in target priority away from the RAF Fighter Command to London; a decision made personally by Goering himself. However, a contributory factor that played an equally important role was that of intelligence failure, which in turn influenced the decision-making and targeting process at the highest levels of the Luftwaffe. The lesson is that when the margin for victory is narrow, even the slightest mistake in decision-making and the application of air power will prove to be critically detrimental to success.

The Bomber Offensive is a campaign that is still mired in controversy regarding its efficacy, the prohibitive losses suffered by the attacking force and the morality of carrying out area-attacks. Strategic bombing is crucially dependent on two factors for success—the policy and direction of the campaign from a political perspective and target selection vis-à-vis its impact on the adversary. Air power is the most

agile of power projection capabilities, but its inflexible application can make it seem a cumbersome capability. The signal lesson that emerged from the bomber offensive, stemming from the phenomenal losses that the allied bomber fleet suffered, is the supreme importance of obtaining and maintaining air superiority.

It was only at the end of World War II that a proper understanding of the concept of securing control of the air in order to ensure the unrestricted use of the air domain to carryout offensive operations against the enemy in all three physical domains—land, sea and air—became clearly enunciated. More importantly, it became accepted as a fundamental tenet for the success of all military operations. This central truth was repeatedly affirmed in the conflicts that followed World War II. Further, the ubiquity of air power became clear in the aftermath of World War II. Ubiquity in this sense means that air power is not only an 'envelope' capability, but one that is critical to the success of military operations in the domains in which other Services dominate.

In the first 50 years of the journey of air power as a military power projection capability, it had moved from what was essentially a secondary capability to one where its ubiquitous nature made it critical to success.

The Air Power Journey Part II: From Ubiquity to Dominance (#326)

Key Points

- *The culmination of World War II also saw technology becoming predominant in the development of air power capabilities.*
- *The stark lesson that was learned in Vietnam was that irregular wars do not automatically lend themselves to the doctrine of 'bombing-to-win'.*
- *It has been demonstrated that modern air power has the overarching ability to become an envelope force that can, when required, dominate the battlespace.*

The ubiquity of air power as a power projection capability was demonstrated during World War II and subsequently accepted by most military strategists. The culmination of World War II also saw technology becoming predominant in the development of air power capabilities—the atomic bomb, radar, surface-to-air missiles, and jet engines creating near-revolutionary changes to concepts of operations and the direct application of air power. It will not be an exaggeration to state that air power capabilities improved by leaps and bounds in the immediate aftermath of World War II.

Between 1945 and the 1991 Iraq War, air power went through its own troughs and crests and eventually emerged from the artificial constraints that had been placed over it as a dominant force. Command and Control systems were placed in airborne platforms, electronic warfare took on a completely different meaning and perhaps more importantly, exploitation of space became a reality, while microprocessors maximised the merging synergies of air power.

If the 1991 Iraq War epitomised the real coming of age of air power, warfare between 1945 and 1991 provided some indication about the troubled developments that it went through. The challenges that air

power faced in delivering its promise should always induce caution in claiming primacy for air power in the application of force.

In the early years after World War II a number of colonial conflicts took place, where air power was once again relegated to its secondary role, mainly because the adversaries to western forces did not possess adequate air power capabilities to even peripherally contest control of the air. Air power was primarily relegated to being employed in support of ground forces who were conducting the core operations in the campaign. The entire concept of strategic bombing and air superiority became inconsequential to the final outcome of the campaign.

From a historical perspective, the Vietnam War was a watershed event in the application of air power. Even though the Vietnamese Air Force attempted to contest control of the air, the US Air Force had absolute air superiority and conducted a number of air campaigns unhindered by even the slightest air opposition. However, after flying more than a million fixed-wing aircraft sorties in the war, losing about 700 aircrew and 3,700 aircraft, air power did not 'dominate' the war. Air power apologists have opined that political circumstances combined to reduce the effectiveness of air power, but the end-result was the same—air power did not determine the final outcome of the war.

The stark lesson that was learned in Vietnam was that irregular wars—a term that encompasses, insurgencies, guerrilla wars and all other unconventional conflicts—did not automatically lend themselves to the doctrine of 'bombing-to-win'. The doctrine and strategy of bombing was seen to be applicable only to a fast-paced conventional war against a peer adversary.

The Soviet Union faced a similar situation vis-à-vis air power during their ill-fated intervention in Afghanistan. What can be surmised is that during the conflicts fought in the decades following World War II, from Korea and Vietnam to the brief but decisive fight in the Falklands, air power was not the dominant, but a 'good-to-have' secondary capability. It was very clear that the effective application of air power depended on its relevance to the achievement of the desired political objectives. The

closer air power is to enabling the achievement of political objectives, the more effective and dominant air power would become.

It took a great deal of soul searching and concept-driven technological advancements to once again bring air power to its place of prominence. The next watershed moment for air power was its employment in the Gulf War of 1991. By this time changes had been brought about in the application of force to achieve national security objectives, some of which were evolutionary and some more revolutionary. The major changes were referred to as a Revolution in Military Affairs, which could, in hindsight be called something of a misnomer. The changes to concepts of operations and air power application had been brought about not as a step-change function but in a more graded manner, one development after the other, even though they happened in rapid succession.

By the time the Western nations and their allies went to war in the Middle-East in 1991 to evict Iraq from Kuwait, air power had once again become the core of the concept of operations. This was made possible by technology that permitted air power to deliver on the precision, proportionality and discrimination that had long been promised by air power theorists and strategists. The application of force, when it is deemed necessary, to achieve the political national security objectives has for centuries suffered from its lack of precision. Even though this drawback was in some ways condoned during World War II and to some extent even in the conflicts of the second half of the 20th century, the lack of precision that leads to unintended collateral damage has become taboo in the current context.

This is the exact situation in which air power comes into its own. Technological advances now make it possible for air power to deliver devastating destructive power not only with pin-point accuracy but also with the ability to tailor the destructive capacity in such a way as to make it discriminatory in a controlled manner. In turn, the ability to be discriminatory also ensures that the 'force' applied is proportionate to that needed to achieve the neutralisation of the intended target and the desired effect. Air power is now capable of precise, discriminatory

and proportionate application of force without exception—always and every time.

With this demonstrated capability, air power now influences most concepts of operations, at least in cases where adequate air power capabilities are available to the planners. In the current security circumstances where irregular wars are common, air power itself has become an asymmetric advantage for conventional military forces engaged in such wars. It is observed that most successful irregular war strategies, concepts of operations and battlefield tactics are heavily dependent on the appropriate and optimised employment of air power. This is a testimony to the overarching ability of modern air power to become an envelope force that can, when required, dominate the battlespace.

The air power journey, although it has had many pitfalls along the way, has never been convoluted. The acme of its capabilities were predicted by visionary thinkers in its infancy, although at the time of the predictions being made, some of them would have seemed a bit too farfetched. It is to the credit of the scientists, concept developers, strategists and operators that the vision of air power has been realised in what could only be called a relatively short time-span of a little over a century. Air power has indeed moved from secondary to ubiquitous to dominant.

The Air Power Journey: An Overview (#327)

Key Points

- *Over the past few decades, Western nations have employed air power as the 'first-choice' military capability in a large number of disparate circumstances.*
- *In the aftermath of the limited wars of the late 20th century, air power developed into a capability without which a combined/ joint military force could not function optimally.*
- *A constant factor in this ever-changing irregular war scenario has been the criticality of air power to the success of battles and campaigns.*

Over the past few decades, Western nations have employed air power as the 'first-choice' military capability within the national power equation, in numerous disparate circumstances. Most conventional employment of military forces since 1991 have almost always begun with, or were fully comprised of, a well-planned air campaign that led to subsequent and/or simultaneous surface action. The century-long journey that air power undertook to reach this position of 'first-choice', which could also be called a position of primacy, has been described in detail in previous *Pathfinders* (Nos 325 & 326).

For a number of reasons, Western military forces engaged in contemporary conflicts have become extremely risk and casualty averse and these politico-strategic circumstances are unlikely to change. Therefore, the strategies, concepts and tactics developed for the employment of military forces have had to take cognisance of the altered paradigms and adapt them to suit the prevailing conditions. Accordingly, air power theories and strategies that have so far been found to be relevant and effective would also need to be reviewed and tailored to meet the changing needs of the time.

A century ago, air power came into prominence with its promise of avoiding the appalling attrition of the static trench war that was epitomised by World War I. However, the theories developed by air power enthusiasts at the end of World War I fell short of expectations in operations because air power did not have the capabilities to fully achieve the claims that were being made. Similarly, the industrial web theory—the concept of neutralising the adversary's warfighting capacity through air attacks—developed by the US Air Corps, was also an exercise in wishful thinking at the time they were developed. It was only at the end of World War II that the employment of air power, as anticipated by the early theorists as a means to end the war and limit casualties with the use of 'catastrophic force' became a reality with the use of atomic weapons.

The availability of nuclear weapons, primarily delivered by aircraft, brought about a radical change in the concept for the employment of air power. For about three decades of the post-World War II era, the Western world led by the United States (US), neglected the development of tactical aviation and concentrated on strategic bomber forces in pursuing the theories of flexible response, gradual escalation and the debate regarding first use that finally led to the acceptance of Mutual Assured Destruction.

It took several limited wars in the 1950s, 60s and 70s for air power theorists to go back to the basics of air power and start to develop more sophisticated concepts of operations that fully encompassed the lessons from World War II. The 'nuclear interlude' would have to be considered an aberration in the development of air power theories and strategy. The Vietnam War was a watershed moment in the application of air power. While technology provided air power with capabilities that were unknown until then, and air power produced some spectacular battlefield successes, the Western forces lost most of the protracted campaigns and subsequently the long war. The efficacy of air power as a war-winning capability came under scrutiny—and rightly so.

Even though air power did not prove to be a strategic game-changer in Vietnam, at the operational and tactical level it developed into a

capability without which combined/joint military forces could not function optimally.

Since the most significant developments in air power capabilities—both in terms of concepts of operations and technology-enabled systems—normally took place in the US, the end of the Cold War that brought about a re-orientation of the USAF, also affected the rest of the air forces of the Western world. Post-Cold War, air power was gradually adapted to become an instrument of coercion that was focused on avoiding casualties and collateral damage.

In the following few decades, the fundamental aspects of the employment of air power became embedded within the doctrine of not only air forces, but within the rapidly evolving concept of joint forces that was being embraced by all modern military forces. The need to obtain and maintain adequate control of the air became the *raison d'etre* for the air forces around the world. Further, the strike, airlift and Intelligence, Surveillance and Reconnaissance became accepted as the core roles of air power. The 1991 Iraq War, with its revolutionary concept of a dedicated air campaign preceding the ground campaign, demonstrated the war-winning capacity of resurgent air power capabilities and concepts. Air power had become a concept-driven capability supported by technological innovations, a fundamental change from its earlier technology-driven development.

The 1991 Iraq campaign and the subsequent air campaigns in the Balkans were, both individually and collectively, defining moments in the growth and influential spread of air power. At the turn of the century it seemed that air power had finally fulfilled its promises and also that its development was plateauing. The rate of improvement and the steepness of the developmental curve in terms of capability growth had started to reduce, while the sophistication of the application of air power to achieve strategic objectives had far surpassed any benchmark that had been so far established.

The so-called 'Global War on Terror' unleashed in the early 21st century provided yet another, if somewhat unanticipated, pivotal point in the application of air power. There was a distinct shift in the conduct

and characteristics that continued to evolve as the conflict progressed—to an extent that in the nearly two decades after the initial actions in 2001, the conflict today has very little resemblance to the one that was initiated. One of the constant factors in this ever-changing scenario of irregular wars has been the criticality of air power to the success of battles and campaigns.

The global security environment is such that the possibility of large scale, conventional state-on-state conflict has receded to the background. At the same time the instances of irregular wars have increased rapidly. This trend is unlikely to change in the next two decades. In such a scenario, air power has become the central capability around which concepts of operations are developed for two separate but connected reasons. First, surface forces of an intervening nation are normally not welcome in the host nations because of the affront they would cause to nationalism and sovereignty. Politically such interventions have become unacceptable in most cases. Deployment of ground forces also carries the risk of mission creep and increases the chances of own casualties. The second reason flows from the first. In cases where external intervention is considered inevitable, then the first choice capability is that of air power since it has the ability to intervene rapidly without having to create a large footprint. Air power can also be employed decisively while adhering to the principles of proportionality, precision and discrimination. It is for this reason that irregular war campaigns are predominantly structured around the strike, airlift and ISR capabilities of air power.

In its one-hundred year journey, air power has become the central pillar of power projection capabilities—ubiquitous, agile and precise in its application.

Did the 1991 Gulf War Set an Air Power Precedent? (#328)

Key Points

- *The 1991 Gulf War between Iraq and a UN Coalition led by the United States is considered the high watermark in the employment of air power to achieve both political and military objectives*
- *International consensus permitted the coalition to exploit air power's ability to rapidly project power across the globe.*
- *The circumstances that came together in the 1991 Gulf War to create the spectacular campaign success could well be repeated elsewhere, but such an occurrence is highly unlikely.*

Air power theorists and strategists use the year 1991 to mark a quantum improvement in the development and employment of air power—concepts of operations, demonstration of technological sophistication, the acme of planning and application, tactical excellence—essentially the efficacy and primacy of air power in a sort of 'before' and 'after' explanatory sense. The 1991 Gulf War between Iraq and a UN Coalition led by the United States is considered the high watermark in the employment of air power to achieve both political and military objectives through the application of force.

The Iraqi military forces were formidable—the army had a total manpower of nearly one million men, 5000 main battle tanks, 5000 armoured infantry vehicles and 3000 artillery guns larger than 100 mm; the air force had more than 700 combat aircraft, 11,000 missiles and more than 8500 anti-aircraft guns. Even though the United States' military leadership predicted some aircraft loss in the air campaign, the Iraqi Army was pushed out of Kuwait by an exclusive air campaign initially, followed by a 100-hour period of ground engagement.

In all previous wars, the influence of air power on the final outcome had always been ambivalent and difficult to measure, making grounds

for myriad unresolvable debates. In the 1991 Gulf War, air power was employed in a demonstrably overwhelming and decisive manner, clearly marking a turning point in its application as a war-winning force. The War brought to the fore the idea of a truly three-dimensional aspect to the conduct of wars and emphasised the unfettered dominance of air power, signalling the need to review the conduct of future wars. There was also a belief, especially amongst air power enthusiasts, that there needed to be a fundamental change in the way in which military operations were conducted.

While there remained no doubts regarding the efficacy of air power to conduct a strategic air campaign and that the air campaign was fundamental to the ultimate victory, the 1991 Gulf War also brought out the fact that it was the short ground campaign that finally forced the Iraqi forces to withdraw from Kuwait and agree to all UN resolutions. At the end of the War, there was a scramble to identify the 'lessons' and also to extol the virtues of air power. However, even though air power dominated the War, it did not automatically follow that the conduct and character of all future wars had irrevocably changed. An examination of the circumstances under which the 1991 Iraq War was fought brings out a somewhat different appreciation.

A number of factors came together, as never before, to make the air campaign the most spectacularly successful in the history of air warfare. There was an unusual degree of international support for the coalition; the geography, climate and weather favoured air operations; the coalition had massive technological superiority; and the coalition combatants were far superior to the opposition. In addition, the coalition commanders were able to optimally exploit the advantages to their benefit. International consensus permitted the coalition to exploit air power's ability to rapidly project power across the globe. Direct overflights and air-to-air refuelling facilities were available for the combat air assets and they were supplied and maintained by airlift, which also leveraged the unusual international support for the coalition.

In another first, host nation support—in this case from Saudi Arabia—was far more than simply making airbases available. Perhaps the most

important factor was the ready, in-theatre availability of fuel ensured by Saudi Arabia and its regional allies Oman and UAE. At the peak of the operations, it is estimated that the US Air Force alone consumed in excess of 15 million gallons (aprox 60 million litres) of fuel per day. Another factor was assured access to pre-positioned stocks of stores and ammunition to the Coalition forces in the Middle-East, although access was conditional on the reaffirmation of the host country. The international consensus assured the availability of these stores.

In sharp contrast was the international isolation of Iraq. Although the Soviet Union had in the past resupplied and supported their client nations—North Vietnam continually, Egypt in 1973 and Syria in 1982—this time no spares or reinforcements were made available to the largely Soviet-equipped Iraqi forces. It has been speculated that the awareness of spares and ammunition limitations acted as a constraint on the free employment of the Iraqi Air Force. In fact even their pre-war training was curtailed rather than enhanced as should have been the case.

Two factors standout as having been critical to the scale and rapidity of the air campaign—the unprecedented international cooperation that was given to the US-led Coalition, which has never been replicated since 1991; and the abundant availability of fuel for unfettered operations to be conducted. In any future operations, these two factors would have the same effect on air campaigns as the ready availability of airbases—long-range deployment of air power may be constrained by limited international support.

There is no doubt that the weather in the area of operations directly affected the employment of air power. Although statistics predicted only a 20 percent cloud cover, in actual fact the coalition aircraft encountered double that. Further, the land war, planned to be launched after 30 days of the air campaign had to be delayed by nine days because of inclement weather. Even then the weather during the four-day ground war was consistently bad. Advanced technology permitted the operations to continue although accurate battle damage assessment (BDA) was not possible. The planning objective was to reduce the Iraqi ground forces by 50 percent before initiating the ground war. However, it was not possible

for the command decision-makers to assess the degradation since the BDA was inaccurate.

The Coalition forces had access to superior technology, which was fully exploited—stealth, precision-guided munitions, Airborne Early Warning and Control, electronic warfare capabilities, and air-to-air refuelling. The optimisation of the employment of technologically superior assets was made possible by the intellectual mastery of the coalition forces. In addition, they enjoyed a numerical superiority calculated to have been very near to 5:1. Of course it was fortuitous that the Iraqi senior leadership were not fully conversant with the changes that had taken place in the Western air forces in terms of the development of capability and the completely altered concepts of organisations. They continued to cater for a war much like the one that had been fought with Iran and earlier with Israel.

The circumstances that came together in the 1991 Gulf War to create the spectacular campaign success could well be repeated elsewhere, but such an occurrence is highly unlikely. Yes, air power determined the outcome and it cannot be denied that it could do so again—however, the probability is very low. Technology brought air power very close to realising its full predicted potential, and again while it is possible to replicate, the likelihood is limited. The manner in which air power was employed in 1991 makes for a strong presumption for air power to become the instrument of choice for the conflicts of today. However, careful planning would indicate that in the face of a determined air opposition, the end-results may not be as predictable. The 1991 Gulf War and the employment of air power cannot be considered to have set a precedent for future wars—all wars are unique and so was the one fought in the Middle-East in 1991.

An Overarching View Of An Air Campaign (#329)

The independent employment of air power during World War II ushered in a new era in the conduct of war. It was made abundantly clear to all strategists that air power could directly attack the enemy's centres of gravity—the vital assets that provide the means to wage war, as well as economic infrastructure—without having to defeat their surface forces. This capability in turn made it necessary to develop the basic principles of air warfare that would guide the application of air power.

The questions that emanate from the independent application of air power are: 'what is its purpose and what is it meant to accomplish?' In turn, the secondary question that has to be answered is 'what are the specific objectives that must be realised in order to most efficiently achieve that purpose?' The answers to these questions will provide an overarching view of an air campaign.

The employment of air power is complex starting with the decision-making process at the level of the commander, who has a wide choice of secondary objectives that will support the higher, strategic purpose to be achieved.

Key Points

- *World War II made it clear that air power could directly attack the enemy's centres of gravity without having to defeat their surface forces.*
- *From a warfighting perspective, air power can be considered to be the ability of a nation to wage an air campaign, which means that it refers to air power in-being and not future air power that can be built over a period of time.*
- *An air campaign can create catastrophic damage to adversary centres of gravity because of the precision, discrimination and proportionality that contemporary air power brings to bear.*

Since the options available are numerous, the chances of making a wrong decision is also much greater.

Over the past century of the use of air power as a military power projection tool, air power strategists have developed some well-established principles to guide its effective employment. However, air power itself has developed in leaps and bounds through technology-enabled capabilities, so much so that step-change functions have been more common in its development than in the case of land or maritime capabilities. As air power capabilities improve, the range of choice for its employment also increases and the existing principles—no doubt distilled from the limited experience regarding the application of air power—may not be adequate to ensure the veracity of the decision-making process. It will then become necessary to examine the combination of the available as well as emerging spectrum of capabilities and application of air power in its entirety to deduce the correct principles for its employment vis-à-vis selection of the correct objectives.

Such an examination, if carried out with sufficient integrity, will lead to the formulation of an appropriate strategy and, perhaps more importantly, to the articulation of a forward-looking concept for the employment of air power. This step is significant because from the concept for its employment, the specifications for the development of capabilities and the air power systems that support them will be derived. In other words, the capability-driven development of air power derives from the result of a clear analysis that examines the principles of its employment.

Since the lead-time required to develop and operationalise air power systems can be inordinately long, the overall capability of the force cannot be materially altered within a span of a few months. This is a disadvantage in the development and employment of air power capabilities that has to be ameliorated by forward planning and the creation of forward-looking concepts.

From a warfighting perspective, air power can be considered to be the ability of a nation to wage an air campaign, which means that it refers to air power in-being and not future air power that can be built over a

period of time. There is no scope in this equation to bring up a defensive air power 'wall' behind which state-of-the-art air power can be developed to counter the immediate threat. An air campaign will be fought with air power that a nation has got at the time of going to war and not with air power being developed for the future; a 'come as you are' approach.

In the context of the above explanation and the warfighting definition of air power, air campaign, in a very broad manner, means air operations wherein the achievement of strategic objectives is based on air power capabilities and their independent employment. However, achievement of strategic objectives does not mean winning the war by air power alone. It is conceivable that the strategic objectives of an air campaign could well be to further the progress of an ultimate strategic success of the surface forces. On the other hand, an air campaign may or need not include the direct assistance that air power provides, at the tactical and operational level, to the success of surface forces.

The subtle difference and separation of an air campaign and other air operations that assist surface forces was clear from the first instances of the employment of air power. The first air warfare campaign was the German Zeppelin raids over London that commenced in January 1915. Although the raids, which carried on well into 1916, were completely ineffective and did not create any significant damage, they conclusively proved the efficacy of an independent air campaign at the conceptual level of planning. However, considering the precision, discrimination and proportionality that contemporary air power brings to bear in an air campaign the results in a similar situation could be catastrophic.

While the Zeppelin raids proved the concept of independent air attacks on adversary centres of gravity and modern air power has the capabilities to carry out such attacks, the other side of the coin in an air campaign is the quest for control of the air. Only a nation with credible air power capabilities can conduct an air campaign and from it derive sufficient control of the air. As early as the 1930s, air power theorists realised the need to have adequate control of the air to have sufficient and continuous freedom of action in all domains of warfighting—air, land, maritime and cyber. From this requirement to ensure freedom of

action stemmed the need to carry out other offensive activities such as counter-air campaigns aimed at restricting the adversary's ability to contest control of the air. In turn air defence campaigns, the corollary to offensive counter-air, became the fall back option for smaller forces.

The concept that sufficient air power capable of waging an independent air campaign, when required, to win the next war is not a new concept. Airmen have long been making this argument, effectively stating that such an independent campaign would be conducted within, and in consonance with, the overall objectives of the Joint Campaign. However, an independent air campaign could also be conducted to deter or coerce an enemy in war or a potential adversary in times of relative peace. The concept of an air campaign is not outside the purview of a joint campaign, but sits well within the overall strategic calculation of ends, ways and means of such a campaign.

A Century of Air Power Thinking Part I: Floundering in the Dark (#330)

Key Points

- *Early air power enthusiasts made assertions without either the background history to develop the necessary concepts, or the technological advances necessary to achieve these goals.*
- *During the inter-war years there were contests for the control of air power and its ownership, between the two existing domain-centric services.*
- *At the end of World War II it was clear that air power had to be organised, generated, applied and sustained by an independent, full time body—the Air Force.*

Ever since Guilio Douhet wrote and published his seminal work *The Command of the Air*, air power enthusiasts have struggled to meet the exaggerated claims that were put forward in that futuristic tome. Douhet claimed that a force operating in the third dimension was capable of 'defeating' an adversary, protecting national interests, and in the final analysis ensuring national security by realising the desired national ends. However, these assertions were made without sufficient background history to develop the necessary concepts, and more importantly, the technological advances necessary to achieve these goals not having been realised.

The appalling casualties suffered in the trench warfare of World War I heavily influenced the thinking of the early air power theorists—in particular Douhet, Mitchell and Trenchard. They believed that employing air power in an attack/bombing role could spare nations from another war of attrition like World War I. Following this development, it was logical to select as the main target the will of the people, making it necessary to attack civilians as targets of choice. Technology supported these theories with the development of heavier-than-air bombers, although strike accuracy

was never assured. The belief was that civilian morale could be 'broken' by bombing adversary cities.

Two fundamental drawbacks detracted from the implementation of this theory in the manner in which it was conceived. One was that there was no empirical evidence to support the suggestion that civilian morale could be broken by 'indiscriminate' bombing. The second, air dominance, termed 'command of the air' at that time, was taken for granted in formulating this theory. The necessity to fight to obtain and maintain adequate control of the air, upon which the success of all other operations depended, was not considered as a prerequisite. The employment of this theory during World War II, proved to be less than optimum and is still the source of disconcerting debates and opinions regarding the legal, moral and ethical impact of the bombing campaign of that war.

During the inter-war years, technology continued to enable developments in the physical capabilities of aircraft. There were also contests for the control of air power and also for its ownership, between the two existing domain-centric services. However, independent air forces came into being and different experimental organisational structures were attempted, especially in democracies.

At the same time that strategic bombing was being considered the panacea for the evils of an attrition-led surface war, the US Army Air Forces were developing the concept of attacking the enemy's capacity to fight, which was not merely providing close air support to troops in contact. They developed the industrial web theory as a practical concept to defeat the adversary from the air. This was a novel idea that espoused the employment of air power to strike at centres of gravity deep inside adversary territory in order to disable their capacity to wage war. It was advocated that removing the capacity to fight through systemic paralysis would be far easier than attacking and defeating the will of the people.

The British and American bomber fleets followed these two different conceptual developments and their operations in World War II demonstrate the difference between attacking the will or morale of

the enemy population, and targeting the adversary's ability to make war. The British resorted to night saturation bombing raids, burning down German cities and other urban targets in an effort to weaken the will of the German people, while the Americans resorted to daylight 'precision' bombing of German industries and factories. Here the term 'precision' is being used in a relative manner, since technology did not permit accurate bombing that precluded any collateral damage. Both the approaches produced enormous collateral damage that amounted to punishing the civilian population of Germany and German-occupied territories.

The implementation of theories developed in the inter-war years were seen to be problematic since technology had not yet developed the wherewithal to ensure sufficient accuracy in being able to neutralise the selected target without undue collateral damage. Further it was also seen that 'breaking the will' of the people through aerial bombardment would require the use of catastrophic force, which was not readily available at that time. Only with the advent of the atomic bomb did air power have the capability to apply such force. However, the early atomic bombs also indicated the employment of air power in total war as well as an element to end total war.

The advent of nuclear weapons had a detrimental effect on the conceptual development of air power theories. The thinking was that nuclear weapons would dictate the next war and therefore there would not be any necessity to develop either futuristic concepts of operations or air power capabilities that could operationalise them. This state of affairs continued for almost two decades of the Cold War, when it was conclusively realised that the Mutual Assured Destruction (MAD) that nuclear weapons promised would ensure that they only provided a deterrent factor and would not be actually employed; no 'victory' could be achieved within the concept of MAD. Only then did air power theorists turn their attention to the development of conventional air power.

The overwhelming influence of air power in World War II, brought it to centre stage. There was understanding that air power had to be

organised, generated, applied and sustained by an independent, full time body—the Air Force.

Even though nuclear weapons imposed their pervasive might on the thinking regarding the application of air power, scientists continued to improve all aspects of aviation through technological innovations that enhanced fundamental air power capabilities. The technology-enabled capability augmentation also needed the development of theories and concepts for their optimised application. In the conceptual development of air power it is seen that during times of war and conflict, concepts and warfighting necessities led the scientists to employ technology in novel and even revolutionary ways to provide the capability being demanded by the theorists, strategists and tacticians. However, during times of relative peace, the scientists produce or invent cutting-edge technology that is then given to the operators to develop appropriate methods of employment. The development of concepts of operations, tactics and procedures follows at a slower pace behind the technology development process.

In the past two or so decades, there has been an attempt to ensure that technological innovations and conceptual developments take place in conjunction with each other and not in separate stovepipes. By adopting this methodology, wastages—in developmental and operationalisation time, as well as in resources—can be avoided and new capabilities brought on board at a faster pace. Considering the expansive nature of state-of-the-art air power capabilities, this is a step in the right direction.

A Century of Air Power Thinking Part II: Precise, Proportionate and Discriminate Power Projection (#331)

The overarching employment of air power during World War II ensured that the fundamental roles of air power became clearly enunciated. It was realised that control of the air was an absolute prerequisite for the success of any other operation. This fact was underscored by statements by illustrious army commanders such as Field Marshal Montgomery who stated, 'If we lose the war in the air we lose the war and lose it quickly'. Further, World War II also made it easy to understand the necessity for army-air cooperation in the delivery of close air support to troops in contact and for efficiency of interdiction missions. It could be surmised that, even though reluctantly, post-World War II air power was accepted as equal to both land and maritime capabilities and critical to the success of all military operations. In turn, this acceptance led to most major nations creating independent air forces.

Almost immediately after the end of World War II and the onset of what came to be called the Cold War, the Korean War broke out. From an air warfare perspective, the Korean War was the last time that a Western Military Coalition

Key Points

- *Post-World War II air power was accepted as being equal to both land and maritime capabilities and critical to the success of all military operations.*
- *During the Vietnam War the distinct line that divided strategic and tactical air power gradually started to get blurred; reflected in the renewed importance that was given to targeting and destroying the adversaries 'war-making capacity'.*
- *The recourse to air power as a first-choice capability was reinforced not only by its strategic success but also by the imposition of humanitarian constraints on military operations.*

fought a war without having assured air superiority, which meant having to fight to obtain and maintain control of the air. It also saw the introduction of jet engines that improved the effectiveness of air power. However, the development of air power theory was stagnating with the acceptance that strategic bombing equated to the employment of nuclear weapons with bombers on 24-hour alert and the subsequent introduction of nuclear ballistic missiles. Tactical air power remained a support arm of the land forces—providing close air support and interdiction.

In the initial days of the Vietnam War, air power continued to be used in a similar manner to the Korean War and the earlier World War II. However, as the War progressed, the distinct line that divided strategic and tactical air power gradually started to get blurred. This was reflected in the renewed importance that was given to targeting and destroying the adversary's 'war-making capacity' and thereby neutralise the ability and/or will to fight. This was a subtle acknowledgement of the purely deterrent capability of strategic nuclear weapons and the concept of Mutual Assured Destruction in a nuclear exchange.

By the late 1980s, the Air-land Battle concept that envisaged substituting and/or supplementing land power with the concerted employment of air power had become the accepted modus operandi. The concept was aimed at employing concentrated and synchronised firepower at the critical time and place so that an adversary's quantitative advantage could be limited. Clearly this US concept was created to counter the advantage the Soviet Union had in the European theatre, at the height of the Cold War. For the medium and smaller air forces of the world, the Air-land Battle concept indicated the need to have a combined arms approach to the conduct of operations.

The collapse of the Soviet Union and the transformation of the politico-strategic environment into a unipolar system proved to have a lasting effect on the concepts of employment of air power. The conceptual developments were aided also by rapid technological advances that permitted air power to deliver on what had been mere promises even a decade back. The 1991 Gulf War could be considered

the 'high noon' of the employment of air power. The precision, proportionality and discrimination that air power could now bring to bear in its application was unprecedented in the annals of warfare. In Operation *Desert Storm*, while air power conducted all its traditional roles, it also assumed the responsibility to carry out strikes against a number of strategic targets and battlefield interdiction, independent of, and prior to, the land campaign. Air power had conclusively emerged from the shadow of land power in a role reversal that was to forever comprehensively alter the application of military force.

Although the 1991 Gulf War has been described as the acme of air power employment, it was after its culmination that air power once again demonstrated a new concept—that of aerial occupation. By enforcing no fly zones over Iraq, air power was employed in a nuanced manner to control Iraq and its recalcitrant dictator, Saddam Hussein. This was a first for air power and made possible by the technological improvements that had taken place in the decade preceding the War. Such an aerial occupation would not have been possible without the advanced air power capabilities that facilitated the operationalisation of a very sophisticated concept. With this act, air power had proven its potency and ability to achieve masterful control over territory without having to resort to physical invasion.

The success of the air campaign that was at the vanguard of the 1991 Gulf War led to a number of air power-led campaigns primarily aimed at peace enforcement in troubled spots around the globe. Both Operation *Deliberate Force* and Operation *Allied Force* were conducted under the aegis of the United Nations with mandates to enforce peace. The recourse to air power as a first-choice capability to enforce the collective will of the international community was reinforced not only by its strategic success but also by the imposition of humanitarian constraints on military operations. The ground invasion of troubled regions became difficult to justify and also was seen to lead to greater destruction of the area of operation as well as making the local population turn against the intervening forces. Further, collateral damage suffered in the course of a military operation, although legally acceptable within laid down

limitations, had become socio-politically unacceptable. The assured precision, discrimination and proportionality that air strikes can now deliver made air power the obvious choice to be used as a deterrent, for punitive strikes and employment in the case of more direct action.

A classic air campaign such as the one conducted at the beginning of the 1991 Gulf War is highly unlikely to be replicated. However, the template that was used in 1991 continues to be a useful guide to the employment of air power, especially when an air campaign is being mounted as the lead element in a joint operation. By the turn of the century, air power had reiterated all its core roles and moved forward to employ concepts of operations that catered to the enhanced demand for 'no' collateral damage and a less intrusive intervention for peace enforcement.

A Century of Air Power Thinking Part III: An Effects-Based Strategy (#332)

The 1990s saw the emergence of air power as the military capability of choice for effective power projection. Air power demonstrated that it had an acceptable footprint when employed in an expeditionary mode rather than boots-on-the-ground because of the inevitability of mission creep, extended commitment and the accompanying increased financial overheads. Although air power was successful in achieving the desired end-states in a number of independent air campaigns that were conducted by US-led Western coalitions, especially in the Balkans, it was seen that coercing a recalcitrant adversary through the use of air power alone was an uphill task.

The inability and/or the unwillingness, of the international community to intervene on the ground tempered with the overarching need to rein in genocidal autocrats bent on committing crimes against humanity continued to rely on the 'cleanness' of air power to make the difference. Considering the great improvements in air power performance that had been brought about by technological innovation, it was not

Key Points

- *Capitalising on the air-weapon characteristics, theorists evolved the idea that a judicious combination of precision and rapid response, or speed, could create a mass of its own.*
- *An effects-based strategy for the application of air power is a sophisticated concept that goes beyond the traditional activity of destroying the opposing forces.*
- *Since air power has proven its capacity to tailor its application in order to achieve the desired political end-state, it has moved to the vanguard of national power projection.*

surprising that air power theory also moved forward, much faster than it had in previous decades.

By the turn of the century, air power weapons had demonstrated assured precision, proportionality and discriminatory capabilities and were also capable of responding to fleeting threats at long range. Capitalising on these air-weapon characteristics, theorists evolved the idea that a judicious combination of precision and rapid response, or speed, could create a mass of its own. Further, it was realised that the mass thus created could be applied to create the 'effect' necessary to achieve the desired objectives. The actions initiated to create these effects could be non-kinetic or kinetic and need not involve the traditional destruction of materiel and fielded forces or the support of the land forces. This concept came to be labelled, in a rather straight forward manner, an 'effects-based strategy'.

An effects-based strategy for the application of air power is a sophisticated concept that goes beyond the traditional activity of destroying the opposing forces and links the application of force to the grand strategic objective of going to war, which will always be political in nature. To achieve this direct connection, an effects-based strategy adopts a cycle of strategies that start from *influence* and *shape*, *deter*, *coerce* and only as a last resort adopt the strategy of *punishment*. The core of the strategy rests in the actions initiated to deter and if necessary coerce an adversary to stop actions that are inimical to one's own interests. Essentially, the entire process of planning an air campaign—the selection of targets and the employment of air power to neutralise the targets—is oriented towards creating the necessary effects to ultimately achieve the political objective of going to war.

After the terrorist attacks of 11 September 2001, air power was once again seen to be the instrument of national choice to embark on what was then termed the 'Global War on Terror', starting with Operation *Enduring Freedom* in Afghanistan. While the strategic concept for the employment of air power remained founded on an effects-based approach, at the operational and tactical level there was a subtle shift in the concept for its application. Air power took on the dominant role

of being the strike element, supported by combat controllers embedded within Special Forces ground teams, which enhanced the accuracy of the air strikes.

This methodology, when combined with assured and overwhelming air superiority created devastating effects on the adversary. In the irregular war scenario that developed in Afghanistan, destruction of time-critical targets had an overarching effect on the adversary, the Taliban in this case. Air power had once again tailored its capabilities and adapted to changed circumstances to create the effects necessary to achieve the desired end-state. The flexibility that air power has demonstrated in the past few decades has always been underpinned by the precision, proportionality and discrimination that have become inherent characteristics of lethal air power.

Since air power has proven its capacity to tailor its application in order to achieve the desired political end-state, it has moved to the vanguard of national power projection capabilities, especially in cases where military intervention is warranted. Traditionally such interventions were invariably land-centric, supported by air and maritime assets. Historically it was seen that such interventions invariably led to mission-creep—risking the possibility of a prolonged and tangled engagement—and were resource-intensive in nature. Further, the changing political environment no longer favours 'boots-on-the-ground' and the associated socio-political backlash that comes with undertaking expeditionary, land-centric military interventions. The combination of political expediency and the need to retain the option of a quick withdrawal, if and when necessary, made air power the instrument of choice.

Military interventions can only be undertaken if sufficient capabilities exist and the nation has the will to intervene in an altruistic manner. The will of the nation can be fickle and in contemporary times could be said to balance on collateral damage, particularly when air power is employed and is considered the lowest-risk military capability. Since the intervening nation itself is not under direct threat, collateral damage—either accidental or as a result of adversary's actions such as

using human shields—will invariably inhibit the further employment of lethal force. The fear of collateral damage constrains the employment of air power, especially in irregular wars, where 'winning the peace' is of paramount importance. In this scenario, the adoption of an effects-based strategy through the employment of air power is more likely to succeed than other strategies that resort to purely lethal application of force.

Another factor that influences the planning and conduct of postmodern military operations is casualty acceptance or tolerance limit of a nation. In this calculation 'casualty' does not mean only own casualties, but also the casualties suffered by the adversaries. In irregular warfare, civilian casualties, of any kind, have the potential to become a choke point in the application of force. When there is no direct threat to the nation and the military intervention is an exercise in humanitarian assistance and based on the responsibility to protect, collateral damage and civilian casualties will become limiting factors.

In such an environment, air power's ability to apply force—both lethal and non-lethal—with precision, discrimination and proportionality, to create the necessary effect becomes a vaunted capability. The projection of national power, without any disadvantages has always been a prized capability. In the prevailing security environment, wherein irregular wars and military interventions have become the norm, air power—functioning within an effects-based strategy—provides the strategic decision-makers with a viable capability to be employed as an instrument of state.

The Influence of Air Power on Maritime Warfare (#333)

Key Points

- *The vulnerability of battleships by air power was underestimated at the beginning of World War II*
- *The era of the battleship gave way to the era of the aircraft carrier, the economic viability of which is debatable*
- *Air power has established itself as a critical element in maritime power projection capabilities*

At the dawn of 20th Century a prevailing philosophy of future warfare was that control of the sea was essential to secure and enhance a country's strategic interests; and this control of the sea was to be achieved by the employment of sea power. The writings of US naval strategist Alfred Thayer Mahan that future wars would be settled by decisive naval engagements gained prominence and became a view shared widely by the world's naval powers. This belief led to nations investing heavily in the construction of battleships, which reached its zenith during World War II. However, these theories were developed and accepted before the advent of effective air power. In the maritime sphere, the rise of air power led to the development of the aircraft carrier. Subsequently, through a number of key events, these two developments—air power and its spin-off, carrier aviation—led to the demise of the battleship.

While air power was still in its infancy, General 'Billy' Mitchell of the United States Army argued that air power could be used to devastate maritime assets. Towards proving this theory, he used air power to sink several ships in a live fire Exercise in 1921. He went on to proclaim air power's dominance over the battleship and other naval warships. His view had earlier been reinforced by the sinking of the USS *Indiana* in 1920 by US naval aviators. However, during the final assessment of the 1921 Exercise, naval officials were reluctant to accept that air

power could dominate surface warships since the vessels were sunk under non-warlike conditions. In fact, they concluded that it would be 'improbable' that a battleship could be put completely out of action by aerial attacks alone.

This line of thinking continued well into the 1930s, even though a mock air raid on the military facilities at Pearl Harbor in 1932 once again demonstrated the extreme vulnerability of battleships to air attack. Aircraft from two aircraft carriers, the USS *Saratoga* and *Lexington*, 'attacked' Pearl Harbor and successfully 'sank' a number of ships at anchor in 'battleship row' by dropping bags filled with flour as simulated bombs. While this Exercise should have offered many valuable lessons, the Navy hierarchy ignored them claiming that the Exercise was invalid as low level precision bombing of battleships at anchor was an unrealistic concept of operation. However, the Japanese Navy studied this Exercise carefully and took the lessons on board. Less than a decade later, on 7 December 1941, they successfully replicated this same attack profile to great effect. Following the American losses at Pearl Harbor, the US Navy changed its focus and established the world's first carrier-centered navy, a force that would play a decisive part in the Allied victory in the Pacific Theatre.

The increasing influence of air power on maritime warfare was arguably best demonstrated during the British attack on the Italian fleet at Taranto in November 1940. This was the first naval battle in which one side employed only carrier aviation to achieve its battle objectives. The British sought to diminish or destroy Italy's control of the Mediterranean Sea by attacking its naval fleet. Employing 'obsolete' *Fairy Swordfish* bi-planes from the aircraft carrier HMS *Illustrious*, the British managed to destroy nearly half of Italy's capital ships in one night. The success of this air attack also influenced the Japanese concept of operations in their attack on the US fleet at Pearl Harbor a year later. The Japanese naval planners studied the British concept of launching torpedoes from aircraft in shallow waters and employed the same tactics in their raid on Pearl Harbor.

Just three days after Pearl Harbor, Japanese air power sank the British warships HMS *Prince of Wales* and *Repulse*, off Malaya. The British Prime Minister Winston Churchill would be later criticised for not realising the vulnerability of warships to air attacks, even though the Taranto raid had clearly demonstrated the efficacy of air power against surface ships. He had earlier been convinced by the British Admiralty that the battleship was the key to British sea power and that they could be made 'safe' from air attack as the on-board anti-aircraft defence systems of British warships would make them 'the most dangerous to aeroplanes in the whole world.'

It was not just the Allies that laid their complete trust in the invincibility of the battleship. Although the Imperial Japanese Navy had more aircraft carriers in the Pacific than America at the beginning of World War II, it also possessed the two largest battleships ever built, the *Yamato* and *Musashi*. Ironically, both were sunk by carrier-borne aircraft during the closing phases of the War.

Closer to Australia, during the Battle of the Bismark Sea in 1943, Allied air power decimated Japan's resupply convoys to their troops in Papua New Guinea. This air action was a critical factor in Japan abandoning their plans to consolidate their conquest of the country.

An arguable 'Achilles Heel' in the design of the larger battleships and cruisers was that although air power was seen as a threat, these ships were not sufficiently well equipped to be able to counter concerted air attacks. The size of their main guns—ranging from the Japanese 18-inch guns to the British 14 or 15-inch ones—underpinned the notion that one's adversary would emanate from the seas and therefore had to be 'out-gunned' to ensure victory. The German battleship *Bismarck* boasted 15-inch guns but was initially crippled by air power and scuttled after being attacked by British warships on its maiden voyage. Even as late as 1944, the US Navy launched the USS *Missouri* with 16-inch guns. The emphasis on maritime warfare meant that the heavy guns took priority as the main armament of the battleships at the cost of limiting anti-aircraft capabilities. Air power was not considered a

potent enough threat by the naval planners, even though it had been repeatedly proven that air power could be the nemesis of surface ships.

The demise of very large warships was heralded by air power becoming more effective and the use of relatively inexpensive weapons. The events of World War II demonstrated that air power could cripple and even sink a battleship, a concept that remains relevant today.

The predominance of the battleship in naval warfare in early 20th century gave rise to carrier-aviation, which brought to bear air power against the vulnerability of the large surface ships. The cost-benefit analysis in this exchange—from battleships to aircraft carriers—continues to be controversial. Building a contemporary aircraft carrier involves considerable and nearly prohibitive investment for most nations, with costs running to billions of dollars. On the other hand, the power projection capabilities of aircraft carriers is unparalleled.

Air power, whether carrier borne or land-based, is now a well-established element of projecting sea power. Air defence of a fleet cannot be left to purely organic air defence weapons and need air power projection capabilities to be effective. Control of the sea, which gives freedom of action to a maritime force within a designated area of operations, can only be assured if control of the air above can be ensured.

ISR - The Debate Continues Manned or Unmanned? (#334)

Ever since the pilot of the US Central Intelligence Agency's high altitude reconnaissance aircraft U-2 was shot down over the former Soviet Union and then paraded at a trial in Moscow leading to a major international diplomatic incident, the question of the viability of manned surveillance capabilities has been debated. Other than the political fallout from the U-2 shoot down incident, it also convinced the major air forces of the world that the vastly improved air defence systems being fielded by most air forces made manned intelligence, surveillance and reconnaissance (ISR) missions that relied on direct overflight of the intended target ISR area far too dangerous to be undertaken.

There were two developments that emanated from this perceived danger to manned surveillance flights. First was that there was a concerted move to improve the space-based capabilities to collect imagery and also to gather radar and signal intelligence (SIGINT). However, the resource-intensiveness of developing space capabilities and the sophistication of the technology that was needed, placed space-based ISR beyond the reach of most nations. The second development was the maturation of unmanned surveillance

Key Points

- *There were two developments that emanated from this perceived danger to manned surveillance flights—increased reliance on space-based assets and the development on UAVs.*
- *By the early 1990s manned aerial surveillance aircraft were being used in the lower priority tasks where the threat to their safety was limited.*
- *The Russian takeover of Crimea emphasised the need to ensure that ISR capability should be able to meet the requirements of irregular warfare and also have greater strategic focus for the possibility of state-on-state operations.*

operations. By the late-1990s, unmanned (uninhabited) aerial systems (UAVs) had become the mainstay of ISR missions. The US-led Global War on Terror following the September 2001 attacks on New York and Washington D.C. made the armed UAV, in the guise of the MQ-1 Predator, the weapon system of choice for the application of air power. Their capacity to carry out unobtrusive ISR for long periods of time combined with the ability to swiftly deliver strikes even when the window of opportunity was fleeting, moved them to the vanguard of air power projection.

As a corollary, by the early 1990s manned aerial surveillance aircraft were relegated to the background. They were used in the lower priority tasks of tactical support to forces engaged in peacekeeping, humanitarian aid and disaster relief, and counterinsurgency operations, where the threat to their safety was limited. Electro-optical imaging cameras, SIGINT sensors, synthetic aperture radars, and ground-moving target indicator radars have increased the effectiveness of manned ISR aircraft in the low-tech air defence environment where irregular wars are being fought.

The geo-political shift that has taken place as a result of Russia's resurgence following the 2014 Crimea episode necessitated building an updated intelligence database of the new strategic competitor. Similarly, the need to monitor Chinese military build-up and other activities in the Pacific Rim required the expanded employment of traditional ISR assets. From a Western perspective, the emphasis on peacekeeping after the collapse of the Soviet Union and the perceived end of the Cold War, as well as the focus on the Global War on Terror post-2001, meant that the surveillance and intelligence gathering of Russia's conventional military capabilities had been neglected.

The US and its NATO allies realised at this juncture that although satellites and UAVs could provide a great deal of information, they could not provide the detailed analysis that ISR data collected by a manned aircraft was able to create. Further, it was seen that a significant portion of the Western satellite and UAV capacity was committed to supporting on-going irregular wars in Afghanistan, Iraq, Syria, Somalia, North Africa and other places.

As a cost-effective means of filling this 'intelligence gap', the manned ISR aircraft was an attractive proposition. However, manned ISR missions are also highly sensitive, both militarily and politically and details of missions that are being undertaken are closely guarded secrets. Since technology has changed drastically from the 1960s, which were the heydays of manned surveillance missions, it is possible—through GPS-based flight tracking and ADS-B technology—to track the aircraft that are undertaking clandestine missions. With the same information it is also possible to create an operational pattern and identify the focus areas of the surveillance.

Unlike the older versions, modern surveillance aircraft have very sophisticated sensors that can collect data without entering an adversary's airspace and also monitor movement of military assets. In the past few years these aircraft have been used in surveillance missions over international waters close to the target area of interest within a potential adversary country. Russia has become a primary target for such missions from the Western nations, especially in Europe, the Barents, Black, and Baltic seas. In response Russia has also stepped up its manned surveillance missions, increasing the risk of confrontation.

In the early years of the fielding of UAVs, it was claimed that these vehicles would be less expensive and that their operating costs would be much lower than manned aircraft. Further, it was also felt that they would have a much lighter logistic footprint. In reality, these two promises have not been borne out in operations. The UAVs require a large number of people to analyse the extremely large quantities of data that is collected and also the live video imagery that is generated through 24/7 monitoring of areas of interest. The more sophisticated UAVs require specialised launch and recovery equipment and facilities that in turn need an increased number of ground crew required to support its operations. These drawbacks essentially cancel out the possible advantages that UAVs could have brought to the role of ISR. The only distinct advantage remains the long endurance of these vehicles that give them extended loiter time in uncontested airspace. The full utility of UAVs is reliant on operating in a secure airspace, which in turn relies on manned aircraft gaining control of the air.

Considering all these factors, highly capable, but small manned platforms were developed as the optimum solution to dedicated ISR. Electro-optical and SIGINT sensor packages, similar to the ones carried by Predator and Reaper armed UAVs were packaged into small, twin-engined turboprop aircraft such as the Beechcraft King Air, tailoring them for special missions. These aircraft are now being routinely used in most combat zones and also to monitor military activities in a stand-off mode, close to international borders. They have become the 'surveillance aircraft of choice' because of their cost-effectiveness, ease of operation and versatility.

The Crimea episode was an eye-opener for the Western nations and emphasised the need to ensure that ISR capability is broad enough to meet the requirements of irregular wars and also to greater strategic focus for the possibility of state-on-state operations. The way in which surveillance is carried out and the absolute necessity to have a flexible option available at all times has increased the importance of these smaller manned platforms that are reconfigurable for different mission requirements.

In the past seven decades the ISR capabilities of air forces have come full circle—from total reliance on manned platforms overflying the target area in the 1950s and 60s to unmanned systems becoming the primary surveillance and at times response capability, to smaller and more versatile manned aircraft once again becoming the primary source of ISR capabilities at the strategic level. The UAVs will continue to be employed as tactical level nodes and responders, especially in irregular wars and low-tech environments, but manned aircraft would be the cornerstone of strategic surveillance and intelligence gathering.

The Concept of Expendable Uninhabited Aerial Vehicles (#335)

Key Points

- *The concept of UAVs provided an opportunity to minimise resource and personnel costs associated with the development, operation and maintenance of airborne platforms.*
- *The UAV provided two advantages in the employment of air power—it was cheap to replace and there was no fear of own casualties.*
- *The Loyal Wingman concept envisages a scenario where multiple UAVs operate together and in conjunction with conventional inhabited combat aircraft.*

Uninhabited Aerial Vehicles (UAVs) include both *autonomous systems*, which are capable of completing a mission without any human input and *remotely piloted vehicles*, which receive human input from a central control station outside of the flying vehicle. The fundamental difference between UAVs and missiles is that the UAV is intended to be recovered after its mission for subsequent use, whereas a missile is a single-use entity.

The concept of the UAV was equally intriguing to the developers of air power capabilities and the strategists for different reasons. For the capability development agencies the concept provided an opportunity to minimise the costs—in resources and personnel required—associated with the development, operation and maintenance of airborne platforms. Further, since a human being would not inhabit the airborne system, it was possible to do away with the life-support systems, thereby increasing the payload and also loiter time. From a strategic and operational perspective, it was seen that UAVs could be used to carry out the 'first day of war' missions that were dangerous and often repetitive, thereby avoiding the possibility of own casualties. While this has merit, a shortcoming of

UAVs is that they have almost no self-protection measures and remain vulnerable in a contested air environment.

The fundamental advantage a UAV provided in the employment of air power was that in extreme conditions the vehicle or the system was expendable—it was cheap to replace and there was no fear of an own casualty. Both these considerations would obviously alter the concept of operations and were laudable goals, although the reality turned out to be somewhat different. It was seen that the operating cost of a UAV was very similar to a normal inhabited aircraft and that the personnel requirement for maintenance and operation had also not reduced significantly. In fact the per-hour cost of operating a UAV was slightly higher than an inhabited equivalent. While the strategy of employing UAVs to carry out the 'dull, dirty and/or dangerous' missions still holds true, a number of other factors, primarily the cost, hindered their full employment.

The UAVs and their armed counterparts, while having proved their efficacy, became technologically far too sophisticated and therefore expensive, defeating the fundamental advantage that they were supposed to have brought to aerial warfare. They were not expendable anymore. In the cost versus capability debate, it seemed that capability requirements had taken precedence, making what was conceived as an 'expendable' system almost as expensive as a traditional aircraft performing the same mission. The trend so far is that both armed and unarmed UAVs are far too expensive, especially with their onboard sophisticated systems, to be considered expendable assets.

A new air power employment concept, still in its developmental stage, seems to be starting to reverse this trend. It has become necessary to exploit 'disruptive' technologies to off-set the advances that have been made by potential adversaries in their anti-access, area-denial (A2/AD) capabilities. In the past few years efforts have been underway to exploit the developments that have already taken place in the field of autonomous UAVs in order to enhance operational capabilities.

The US Air Force Research Laboratory (AFRL) initiated a project in 2015, called 'Loyal Wingman' that was meant to exploit the capabilities

of autonomous systems technology to enhance operational efficiency in denied and/or contested environments through combining fifth-generation fighter aircraft with UAVs. The precepts developed in this project have now been adopted by other air forces also and the term 'Loyal Wingman' has evolved into generic usage in air power parlance. The term itself infers control being exercised by an inhabited asset, normally considered to be a conventional combat platform.

Increased reliance on UAVs have become necessary because of the advanced integrated air defence systems and improved electronic attack capabilities have combined to augment the complexity of the prevailing A2/AD environments, which in turn threatens the safety and efficiency of strike platforms. The Loyal Wingman concept envisages teaming conventional fighter aircraft with armed UAVs to reduce the threat to the pilot by assigning the more dangerous tasks within a mission profile to the uninhabited assets. Since the chances of their suffering attrition are high, the UAVs would have to be considerably cheaper than the current set of highly sophisticated ones. However, the effectiveness of this combined system of conventional fighter aircraft and armed UAVs will depend on the ability of the autonomous platforms to coordinate their activities among themselves and also to function in a highly contested environment where human interface is degraded or considered undesirable.

The primary requirements are for Loyal Wingman to be able to distinguish friend from foe autonomously and to communicate information after it has been prioritised, depending on the level of hostility of the environment. Advocates of the concept envisage a scenario where multiple UAVs operate together, and in conjunction with, conventional inhabited combat aircraft. This combination is expected to relieve the human aircrew to focus on broader mission management issues since the cognitive workload of dealing with high-threat environments would be reduced. The uninhabited autonomous platforms offer the ability to penetrate very high-risk mission environments and within the concept could be considered expendable. It is also thought that as the concept develops further and capabilities are tested and approved, the UAVs within the system would also be able to use their own sensors and embedded artificial intelligence (AI) to

function autonomously, while being part of a larger 'swarm' of inhabited/uninhabited aerial vehicles.

The basic premise in the development of this concept is the belief that the UAVs would be expendable—meaning that the autonomous vehicle would be inexpensive enough to not worry the commanders regarding their loss in achieving the desired objective in the employment of air power. By developing UAVs with a higher single-use failure probability and a lower total service-life, they can be made 'inexpensive', although they are manufactured with the capability to be recovered and reused.

The latest initiatives in the development of UAVs are meant to stop the current upward trend in their manufacturing costs and the resource-intensive and sophisticated nature of their embedded systems. Almost all future combat air systems being developed across the world—currently mostly at the conceptual stages—include low-cost uninhabited capabilities as adjunct to conventional combat platforms, adhering to the Loyal Wingman concept in its broadest sense.

It is highly likely that in the next five to ten years, the concept of Loyal Wingman—a judicious combination of low-cost, autonomous, armed and/or unarmed UAVs and conventional fifth-generation fighter platforms—will continue to mature through the development of technology demonstrators and experimentation. However, complete operationalisation of the concept requires the continued maturation and integration of enabling technologies such as AI, sensor fusion and human-computer interface practices.

Challenges To Modern Rotary-Wing Air Power (#336)

Key Points

- *The introduction of sophisticated but relatively cheap air defence systems, have necessitated a fresh look at the inherent capabilities of rotary-wing assets.*
- *Legacy rotary wing assets no longer have the reach, speed, agility, and/or lethality required to positively influence the outcome of a battle.*
- *Improving the performance envelope of helicopters, increases survivability but also the efficiency in their critical roles.*

From its inception and subsequent operational induction, helicopters have become an integral part of battlefield air power. Even as 'vertical lift' capabilities became a crucial component of a holistic air power capability, they remained vulnerable to adversary action when operating in contested airspace. This was not considered a major inhibiting factor to the employment of rotary-wing airlift assets in combat zones, since the operating airspaces in the campaigns of the past few decades have been benign, which permitted helicopters to operate through the full extent of their operational spectrum without being unduly threatened.

However, two unrelated factors have gradually changed this paradigm. First, the introduction of sophisticated but relatively cheap and readily available air defence systems into the battlespace, even in irregular warfare campaigns, have necessitated a fresh look at the inherent capabilities of rotary-wing assets and also their *modus operandi* in combat zones. Second, the typical irregular war scenario has evolved over the past two decades, moving away from pure counter-insurgency operations towards a potential for high-end conflicts with peer or near-peer competitors. This is so because the airspace over contemporary conflict zones have become congested, divided and controlled by different entities

with sufficient air-denial capabilities to enforce such control. Combat zone airspace has evolved into a more technologically challenging one, which was not the case even two decades ago.

Although the changes to the battlespace have been gradual, they have manifested in a clear understanding that legacy rotary-wing assets will no longer be able to provide the necessary capabilities that had earlier made them come very close to being a deterrent force in irregular war scenarios. They no longer have the reach, speed, agility, and/or lethality required to positively influence the outcome of a battle. More importantly, they do not have the level of assured survivability that would permit their uninhibited employment in a modern battlefield.

It is a paradox that while the employment envelope of helicopters has continually expanded, the development of their performance envelope has remained somewhat static because of technological constraints. Their operating environment makes them vulnerable to both the look-down shoot-down capabilities of fighter aircraft and small arms fire from the ground and/or surface-to-air missiles.

Helicopters now have several primary battlefield tasks—transport, attack, medical evacuation and Special Forces operational support. There is now renewed efforts being made to overcome the limitations of rotary wing assets so that their true potential can be realised. Concepts and technologies are being developed through innovative employment of cutting-edge developments in aerodynamics, flight controls, structures and materials through modelling and the use of analytical tools.

A great deal of research is being focused on the biggest technical challenge that faces helicopters—overcoming the speed barrier, which is approximately 175 knots for a conventional rotary wing craft. The inability of a helicopter to push past this speed limit is caused by a phenomenon, generically termed 'dissymmetry of lift'. In order to understand this at a very basic level, it can be explained as being caused by the development of unequal lift in the advancing and retreating halves of the rotors, that create a spinning disc as the helicopter flies. Design engineers are still struggling with the challenge of increasing

the speed of conventional helicopters, as fixing one issue aggravates another. Innovations to solve this fundamental challenge through design configurations and rotor-blade technologies are on-going.

Another area of interest for finding a solution to the speed barrier is engine technology, acknowledged as one of the most important factors for the design and development of future rotary wing capability. In this sphere a number of technological developments are also being attempted to enhance capabilities for helicopters—turbine engines are being trialled and electrical and hybrid propulsion systems are being studied. With the concerted efforts being made at improving its performance, the future helicopter is going to be faster and will also have greater range than the ones operating today. However, from a military operational perspective, enhanced survivability is perhaps the highest priority, which in turn requires combining a number of new technological developments. It will require not only enhancing the aircraft performance envelope in terms of speed and range, but also masking its acoustical, visual, infrared and electronic signatures.

Its distinctive noise has always been a defining element in helicopter operations. Acoustic signature reduction in all phases of the flight profile will reduce the advance warning of an approaching helicopter, thereby reducing the reaction time of the adversary and increasing the probability of survival. Visual, radar and electronic signature reduction is also being considered to improve the survivability of rotary wing assets. Although low observable or stealth technology has so far been limited to fixed wing fighter and bomber aircraft, helicopter power and propulsion systems are being designed to reduce both acoustic and infrared emissions and airframes are now being coated with radar-absorbent material. Reduction in the electronic footprint may not be of primary importance in irregular war situations, but assumes much greater significance in a peer or near-peer conflict and as adversaries develop and/or acquire more sophisticated electronic warfare capabilities.

Improving the performance envelope, especially in terms of speed and range, not only increases survivability but also the efficiency of

helicopters in their critical roles of Special Forces operational support and casualty evacuation. In casualty evacuation situations, the faster a medical team can reach a casualty, better the chances of survival and recovery. Increased range will also influence the efficiency of helicopter medical evacuation since the aircraft would not have to land en-route in order to refuel, if the casualty is out of the range of a legacy helicopter. The advantage of increased range is that the helicopter itself could be based outside the reach of the adversary's weapon systems while still being able to carry out its mission with no apparent loss of time.

A challenge facing rotary wing operations that has not yet been effectively addressed is the question of their efficacy in functioning in a contested airspace against a peer or near-peer adversary. The answer may partly lie in modernising the rotary wing fleet to keep pace with the advances being made in hypersonics and artificial intelligence. There is no doubt that helicopters provide an unquestionable flexibility to battlefield operations and to surface forces in contact with the adversary through their ability to provide dedicated fire support and casualty evacuation. Their ability to insert, sustain and extract Special Forces elements with ease into contested areas acts as a force multiplier to a numerically-challenged force, which needs to contain a large geographical area. However, unless rapid improvements are made in their performance envelope and design features to mask their signatures—acoustic, infrared, electronic—incorporated, the general utility of helicopters and the flexibility they provide to surface operations would enter into a declining spiral.

A Case For Multi-Role Combat Aircraft (#337)

Key Points

- *The demand for ever better performance—which meant having more powerful engines and sophisticated aerodynamic designs as well as missiles with greater range and accuracy—led to the increase in cost of combat aircraft.*
- *By the time the third generation fighter aircraft were fully matured and their capabilities were being incrementally improved through upgrades, they had become far too expensive for most nations to maintain sizeable fleets.*
- *The main advantage that an MRCA provides to an air force is cost-effectiveness in a number of ways.*

Combat aircraft have been classified effectively into 'generations' based on their capabilities and some characteristics. They have also been separated into air superiority or air dominance fighters, strike, electronic warfare, and reconnaissance aircraft, based on their primary role. Further, these aircraft were custom designed to optimise them for their designated roles in terms of aerodynamics, engine performance and weapon carrying capacity. The result was that most air forces carried an inventory of a large number and types of aircraft with their own dedicated maintenance and other support systems. Since the per-unit cost of these first and second generation fighter aircraft were relatively low, the concept of role-dedicated combat aircraft was not considered a drain on resources. (See *Pathfinder No 170, January 2012, Five Generations of Jet Fighter Aircraft*, for a detailed explanation of the rationale for classifying fighter aircraft into different generations)

The demand for improvements in performance was the primary catalyst for the increase in cost of combat aircraft. Better performance from an aircraft point of view meant having more powerful engines and sophisticated aerodynamic designs; and from a weapon

effectiveness perspective it demanded missiles with greater range and accuracy. Every improvement that was introduced came with an increased cost-coefficient that in turn multiplied the overall cost. While the cost difference between first and second generation aircraft were marginal and acceptable, the difference between second and third generation aircraft was a quantum jump. The initial third generation fighter aircraft continued to be role-dedicated. However, as the cost escalation started to impinge on the numerical size of available forces, a re-thinking on single-role fighter aircraft started to take place.

The first development was to take an airframe and engine and to adapt it to different roles by changing the avionics and weapons. With very limited changes the same aircraft could be fine-tuned to be an air defence/superiority fighter or a dedicated ground attack/strike aircraft. Both the Western nations and the then Soviet Union adopted this methodology to ameliorate design and development costs by manufacturing larger numbers of airframes and engines. The added costs were only for the avionics, especially in the case of air combat versions, where an air-to-air radar had to be installed. The Tornado in the West and the Mig-23 'Flogger' in the Soviet inventory are examples of this concept.

By the time the third generation fighter aircraft were fully matured and their capabilities were being incrementally improved through upgrades, they had become far too expensive for most nations to maintain sizeable fleets. The inability of medium and small air forces to invest the necessary resources to create and maintain the required numbers of combat aircraft led to technological innovations being implemented to overcome the shortfall in 'capabilities' that reduced numbers of fighter aircraft. The concept of the Multi-Role Combat Aircraft (MRCA) was born more out of necessity rather than as a technological improvement of existing platforms.

MRCAs by design are intended to perform different roles in the air, normally one of them being air-to-air combat. The term indicates the employment of a common airframe and engine(s), and a platform, to carry out multiple roles by adapting the weapon carriage capacity. This concept is substantially different to the employment of third generation

aircraft like the MiG-23 in different roles, achieved by substantially altering their avionics and weapons suites.

Normally an MRCA is made capable of undertaking the two fundamental roles of air power—air-to-air combat to achieve control of the air and strike to neutralise targets on the ground. This is achieved by externally reconfiguring the aircraft on the ground, depending on the envisaged mission that it is likely to undertake. The main advantage that an MRCA provides to an air force is cost-effectiveness in a number of ways. An MRCA ensures that the ground support required for the maintenance of the aircraft, irrespective of the role that it is being employed for at any given time, is streamlined and therefore not resource-intensive. The only requirement is to have the different weapon suites made available in sufficient quantities. The MRCA concept was operationalised with fourth generation fighter aircraft and continues to influence the acquisition process of modern air forces.

The early multi-role aircraft were adapted from the air-superiority/dominance fighter, which were optimised for the air-to-air combat role. As a result, the strike capability was somewhat restricted because of weapon carriage limitations. Even so, another advantage came to the fore—these aircraft were capable of 'looking after' themselves even when they were being utilised in the strike role. If intercepted, they could jettison their heavy strike weapons and then defend themselves from adversary attack. The spin-off was that a medium or small air force could now limit the number of combat platforms that they had to acquire in order to provide the nation with a credible strike and air superiority posture. However, these aircraft suffered a disadvantage of being optimised for one role and therefore, their performance in the second role becoming less than optimum. The difference in performance between the roles is a trade-off that detracts from the true potential of multi-role combat platforms.

As the MRCA concept took hold, and was seen as a viable option, a number of other specialised roles started to get added to the multi-role construct. Electronic Warfare, suppression of enemy air defences (SEAD),

and tactical reconnaissance could be carried out by the same platform by merely configuring it with the appropriate weaponry or specialised pods.

Another innovation made the concept of a multi-role aircraft truly live up to the meaning of the term. The earlier fourth generation fighter aircraft could switch their role on the ground. Switching roles meant that the aircraft would have to be reconfigured on the ground with the special weapons and pods necessary to carry out a particular role. In case the role had to be changed, the reconfiguration could only take place once the aircraft had landed. However, the later versions of the fourth generation aircraft, sometimes referred to as 4.5 generation fighter aircraft, were capable of changing the mission profile while in flight—a capability that came to be termed 'swing-role'. Swing-role meant that at any given time during a mission the aircraft could be tasked to change the role it is undertaking and then be utilised to carry out another completely different role.

The capacity to swing-roles gives a different meaning altogether to the idea of weapon platform flexibility and is a coveted capability. This is particularly so for medium and small air forces that are constantly under pressure to limit resource expenditure while also having to meet the capability requirements to achieve national security imperatives. Role-dedicated combat platforms can only be afforded by resource-rich and large air forces and has become unaffordable for all others. There is no doubt that a case exists for multi-role fighter aircraft to be further developed to ensure that they are equally optimised for any role that a combat platform should be able to undertake.

Challenges to the Suppression of Enemy Air Defences (#338)

Key Points

- *S/DEAD missions have played a critical role in the effectiveness of air power projection for more than five decades.*
- *With the improvements in air defence capabilities and also their proliferation, the conduct of a sequential air campaign may not be a feasible prospect anymore.*
- *The modern integrated air defence networks will not permit unfettered operations in a contested environment without creating unacceptable losses on the attacking force.*

The suppression/destruction of enemy air defences (S/DEAD) has played a critical role in the effectiveness of air power projection for more than five decades. However, the emergence of extremely sophisticated air defence systems and their easy proliferation has created substantial challenges to the efficient prosecution of S/DEAD missions. Modern air defence systems are built around extra long-range 'double-digit' surface-to-air missiles (SAM) and associated anti-access/area denial (A2/AD) technologies that combine early warning and ground control intercept radars and radar directed air defence artillery systems. These developments have diminished the effectiveness of S/DEAD missions, which in turn makes it difficult for air power to obtain and sustain the necessary level of control of the air.

This gradual shift in the capability balance between air defence and strike options has manifested itself in the extended period of time that air forces cater for in their plans to neutralise the enemy air defence network, which is a prerequisite to achieve control of the air. Western air forces have not had to fight to obtain control of the air since the Korean War and

therefore, the changing circumstances might come as a surprise to most. It is also a fact that Western nations have not been required to combat a near-peer adversary since the end of the Korean War.

Anti-aircraft capabilities have improved in leaps and bounds in the past few decades—the threat to attacking aircraft and their crews have become uncomfortably high, especially when the conflict is with a near-peer adversary. The improvements have also increased the survivability of air defence systems and effectively neutralising them could take several days. This leads to a situation where other roles such as strike and even control of the air may have to be undertaken while the adversary's air defences are still active and a threat to air power systems. The situation would necessitate an air force having to carry out all of its roles simultaneously with S/DEAD missions. The possibility of increased attrition levels to one's own forces cannot be ruled out in such a scenario.

With the improvements in air defence capabilities becoming prevalent and also the availability of cheap air defence systems increasing in proliferation, it could well be that the earlier sequential conduct of an air campaign—where S/DEAD was carried out in the 'first-day' of war to be followed by strike support to other elements of the joint campaign—may not be a feasible prospect anymore. Adversary air defence networks will be more robust and also mobile, which would make their neutralisation difficult and definitely not containable in the first few days of war, if minimal effort was applied.

All air forces would now have to prepare for a prolonged S/DEAD campaign while also being able to undertake other joint campaign missions simultaneously. This is not to suggest that the S/DEAD missions are not part of the joint campaign, they most clearly are; although aimed directly at neutralising the threat to air assets and therefore prone to being considered purely 'air' missions is a somewhat warped understanding of the overall campaign. The onus of responsibility to provide strike support to the joint campaign continues to be that of air power, which makes it imperative that adequate strike and close air support (CAS) is provided from 'Day One' of the

campaign. Taking into account the different missions that an air force would be required to provide from the outset of a campaign and the resource-constrained numerical status of medium and small air forces, it is not difficult to envisage the pressures that will be placed on air power. The strain of asset allocation and the conflicting demands to enforce S/DEAD missions will challenge the planning premises of the air campaign within the joint campaign.

In a modern conflict against a peer-adversary, the battlespace will be lethal for air assets conducting all missions and virtually no altitude or speed will be safe. Developments in Anti-Aircraft Artillery (AAA) pose a crippling threat to aircraft, especially the ones engaged in providing CAS that are relatively slower and forced to fly low. Unlike earlier AAA guns that were individually stand-alone and had a slow rate of fire, modern AAA are normally linked to the integrated air defence systems. They also have electro-optical and infra-red sensors and radar guidance, which greatly improve their effectiveness. In the modern concept of operations, most missile sites, other high-value targets and vital areas are defended by AAA batteries. The only way to neutralise these sophisticated AAA batteries is to have a sufficient long-range air-to-surface missile capability within the S/DEAD force. The cost-benefit analysis of this exchange may not always favour the S/DEAD force element.

Uninhabited Aerial Vehicles (UAVs) have been considered as part of the answer to the increasing threat from air defence systems. Since they are relatively cheap they are cost-effective, although the loss rate in an attack against an integrated air defence system may not be sustainable. The AAA batteries are being optimised to counter the newly emerging swarming UAV concept. The battle between the need to defend and to defeat an emerging air defence system and the concept of a system is now being revisited.

Adding to the challenge of S/DEAD are the advances taking place in the SAM systems that have both passive and active sensors and can also cover extended areas. The integrated air defence network of Russia, for example, cover much of the Baltic and Black Sea regions. Similarly

China has extended its air defence network far into the South China Sea in pursuit of its own version of the A2/AD concept. SAM systems remain the major challenge to all air operations in a future conflict scenario. Long-range, stand-off air-to-air weapons provide a modicum of anti-SAM system capabilities, although the cycle of defence and suppression could at the moment be considered to be tilted in favour of the air defence network.

The battlespace of the future is unlikely to be one of isolated AAA and geographically static SAM systems. The air defence networks are going to be dense, integrated, and mobile, with both passive and active sensors and ranging across the electro-magnetic spectrum. They are also going to impose a high attrition rate on aircraft and UAVs engaged in S/DEAD as well as other strike and CAS missions. The current fleets of combat aircraft in medium and small air forces are such that it is difficult to believe that attrition has realistically been included in the force-structure planning. The modern integrated air defence networks will not permit unfettered operations in a contested environment without creating unacceptable losses on the attacking force. For medium and small air forces, the challenge to achieve success in obtaining and maintaining control of the air just went up.

Suppression of Enemy Air Defences an Evolving Operational Concept (#339)

Key Points

- *The campaign to achieve control of the air has two distinct elements within it—suppression of enemy air defences, and offensive and defensive counter air operations.*
- *Where an adversary is heavily reliant on air denial capabilities, its destruction is likely to bring the adversary to the negotiating table.*
- *The way forward to provide assured freedom of manoeuvre for friendly forces, while denying the same to the adversary, is only through joint planning and execution of SEAD missions.*

Achieving and maintaining adequate control of the air, especially in contested environments, is a fundamental prerequisite to ensure the success of all military campaigns. The campaign to achieve control of the air has two distinct elements within it—suppression of enemy air defences (SEAD), and offensive and defensive counter air operations. SEAD operations are aimed at neutralising or destroying enemy air defences that include not only surface-to-air missiles (SAMs) and anti-aircraft artillery, but also enabling systems such as early-warning and fire-control radars, command and control nodes, and communications systems, which combine to create an effective air defence system. Suppression can be achieved through either the physical destruction of the system or through electronic warfare that neutralises the air defence systems.

Even though enemy air defence sites were targeted during World War II and then the Korean War, SEAD remained an undefined mission, since it did not form part of the overall strategy and was not considered within the doctrinal make-up of the force. Over the course of the conflict the Vietnam War was a watershed moment in the evolution of what would come

to be known as SEAD. The North Vietnam Army had developed an integrated air defence system (IADS) aimed at air denial, built around SA-2 'Guideline' SAMs. This forced the USAF to introduce dedicated SEAD aircraft, termed 'Wild Weasels' that fielded advanced technology and effective tactics. The optimised combination of hard-kill, electronic warfare and command and control countermeasures altered the kill ratio of the IADS from one aircraft destroyed for every 13 missiles fired in 1965 to one hit being recorded for every 68 missiles fired by the end of 1972. The optimisation of tactics and technology laid the foundation for future developments in SEAD missions.

There was a more strategic outcome to the success of SEAD missions in 1972, which was part of Linebacker II, an 11-day air campaign over North Vietnam. The employment of the B-52 bombers in attack missions without sufficient tactical SEAD support, led to the loss of 11 bombers in the first five days of this campaign. This prompted the decision to commence an all-out attack on the North Vietnamese air defence network. In three days the North Vietnamese leadership agreed to negotiate. The first concerted attack on the IADS left the Vietnamese defenceless and open to air attacks, which brought them to the negotiating table. Although not emphasised sufficiently, this is a signal lesson to be taken forward in similar cases, where an adversary is heavily reliant on air denial capabilities as opposed to attempting to achieve contextual control of the air.

The post-Vietnam War era was marked by the development of advanced Anti-Radiation Missiles (ARMs) and electronic warfare assets to enhance SEAD capabilities. As a corollary, IADS also improved their capabilities and resilience to counter ARMs and electronic attacks. (For details see *Pathfinder No 338*, August 2019) The air campaigns of the last few decades—the Persian Gulf War in 1991, Bosnia 1995, Kosovo 1999, Iraq 2003, and Libya 2011—demonstrate the increasing effectiveness of IADS and the critical role of SEAD operations as a prerequisite for achieving the necessary control of the air. The success of SEAD operations in the past few decades has been underpinned by the flexible and holistic approach adopted by the Western air forces

that combined traditional hard-kill missions by ARMs and electronic warfare tactics to neutralise sophisticated IADS.

The race to counter attacking aircraft and the need to neutralise the IADS of the adversary is cyclical with neither capability managing to be a sure winner even on a semi-permanent basis. Operation *Allied Force*, the 1999 air campaign in Kosovo provides a typical, if complex, case study. The Serbian air defences were numerically not very large, but they took steps to protect their IADS through dispersal and practising emission control to avoid detection and balance their lethality with survival. NATO assets launched over 750 ARMs and 12 percent of all combat sorties flown were SEAD missions. In Kosovo the success of SEAD was more a function of the Serbian forces' lack of external support and the inferiority of their equipment than the effectiveness of Allied SEAD operations and it came as somewhat of a surprise that they managed to shoot down a stealth F-117A fighter aircraft with a surface-to-air SA-3 missile.

Both ARMs and electronic warfare capabilities have been evolving over the past few decades. Similarly air defence and air denial capabilities have also kept pace with the advances in SEAD operational capability. The evolution in SEAD can be traced from the threats that it has to defeat, from focused air denial to IADS and the increasing primacy of strategic air power. From its inception as a sub-set mission to destroy surface-to-air missiles, SEAD had evolved into a more generic application of air power to neutralise the adversary's ability to defend from air attacks; moving from a mere secondary support role to a critical, first-day-of-the-war mission with the rapidly increasing air denial capabilities that are being inducted into even small power military forces.

With most modern military forces moving conceptually towards joint and integrated operations, it is not surprising that SEAD is also being conducted within the 'joint' ambit. The neutralisation of the Iraqi IADS during the Gulf War 1991 was a classic example of joint operations—the US-led coalition used air, land, Special Forces and naval forces to degrade, destroy and suppress the enemy's air defence systems using a variety of weapons and effects. Even though the Iraqi air defences were intimidating, in the past three decades after 1991, the air defence networks have become formidable. The easy availability of sophisticated technology such as low observable and uninhabited systems, advanced communications and computing capabilities, and advances in cyber and space domains will contribute to increasing the complexity and asymmetry of future battlefields.

Realistic simulations and exercises have shown that while modern IADS will continue to be a critical challenge, the more pervasive 'anti-access and area-denial' strategies will almost completely preclude the effectiveness of traditional SEAD missions. SEAD itself takes on a much broader meaning as compared to its conventional understanding. The way forward to provide assured freedom of manoeuvre for friendly forces, while denying the same to the adversary, is only through joint planning and execution of SEAD missions with broader objectives. In other words, joint SEAD missions are the foundations on which all future campaigns have to be planned and executed for success.

The Cost of Air Power (#341)

Key Points

- *Throughout history governments have protected their national interests through the investment in military hardware.*
- *Mass aircraft delivering inaccurate weapons has given way to fewer aircraft delivering more accurate precision weapons with a greater survivability rate for aircrew.*
- *The cost of the technology behind fewer aircraft delivering the desired air power effects will continue to challenge governments in maintaining a credible air force.*

Throughout history social commentators have claimed that war is inevitable and societies have gone to great lengths to seek victory or resolution by investing in military hardware to protect their national interests. Since its inception, air power has been at the forefront of conflict, being used in a range of roles from deterrence to delivering kinetic effects when diplomatic efforts have failed. The measure of the effectiveness of kinetic effects has not only been costed in terms of neutralising an adversary but also the attrition rate of one's own aircraft and the loss of aircrew. These calculations have led to the mass application of air power giving way to fewer aircraft creating the desired effect, facilitated by advances in technology.

Calculating the cost versus benefit equation of warfare is not new. It has been calculated that to kill one enemy soldier cost Caesar 75 cents and Napoleon $3 000. The World War I cost of a fatality was $25 000 which had doubled to $50 000 in World War II. The Word War II costing also saw a significant jump in the cost of aircraft manufacture, with the unit cost of a Lancaster bomber going up from 45 to 50 thousand pounds.

However, even in wars of necessity, treasure and other resources to expand on military equipment will be scarce. For this reason,

during Word War II, Germany, Britain and the United States closely monitored the attrition rate of aircraft. There are a number of examples of unsustainable attrition rates, especially in World War II. In late 1943, the strategic bomber offensive against Germany was starting to take its toll and in early 1944 Germany responded by launching a series of bombing raids around the greater London region, termed the 'Baby Blitz'. Germany assembled and employed a fleet of 474 bombers but lost 329 of these aircraft over a five month period. This high attrition was because Britain had learned from its experience in the earlier Battle of Britain and invested in improved ground-based air defence systems which reportedly included using anti-aircraft rockets for the first time. They had also developed better tactics to enhance counter air capabilities.

In retaliation to the German offensive, Britain launched a raid on Nuremberg on the night of 30/31 March 1944 which ended in a great loss for the Royal Air Force (RAF) and achieved only marginal results. The attrition rate of aircraft and aircrew in this raid was the highest for RAF Bomber Command during the entire war. Of the 779 bombers that took part in the attack, 106 aircraft were either shot down or written-off after landing with the RAF suffering a loss of 545 aircrew.

The United States Army Air Force suffered a similar fate in 1943 in the attack on the Schweinfurt ball bearing plant. Lacking adequate fighter cover, only 62 of the 260 aircraft that took part were left unscathed and over 600 aircrew were either killed or taken prisoner. The P51 Mustang would later provide the much needed fighter escort duties.

The cost versus the effect arguably reached the zenith of its return with the development of the atomic bomb which was seen as a technological marvel at the time. However, the dropping of the bombs on Japan to conclude World War II would not have occurred had it not been for the heavily modified B29s that dropped the bombs. Ironically, the development and production of the B29 aircraft was more expensive than the development of the atomic bomb itself. Furthermore, of the

total 3943 B29s produced, 562 were destroyed, thereby incurring a huge loss.

Such losses were unsustainable and the concept of large numbers of aircraft dropping inaccurate weapons had to change. The Vietnam War became a watershed moment in the application of air power not only in terms of improved accuracy of targeting but also in catering to the need to arrest the escalating cost of air power.

Early in the Vietnam War it was seen that the World War II strategic bombing concept did not work as this was a different type of war. Rather than relying on mass to achieve a mission outcome, advances in technology such as the introduction of precision guided munitions (PGMs) and modified targeting techniques improved the application of air power. As an example and to explain this progression, in World War II it would take a hundred B-17 aircraft to neutralise a ground target because poor targeting techniques resulted in very high miss rates. By the 1960s it took four F-4 Phantom fighter-bombers to successfully hit the same target. By the 1980s, a single F-117 stealth fighter employing PGMs could obtain the same success rate while achieving an excellent self-survivability rate. It is now estimated that an F-35 could achieve the same success rate as the F-117 but at a much lower unit cost. The average cost of the F-117 variants was $111 million compared the average cost of the F-35 variants being $100 million and this price is predicted to come down. Essentially, more accurate targeting with its attendant support technology together with updated concept of operations and doctrine has meant that it takes fewer aircraft to neutralise a target. Employment of fewer platforms also means that greater planning is required in allocating these limited assets through an Air Component Commander in an Air Operations Centre exercising centralised control of all air assets in a theatre while permitting decentralised execution through a local commander.

While the cost of modern aircraft and associated weapon systems consumes a large portion of the Defence budgets of countries that seek to have credible air forces, it seems that this is less than the cost of operating a larger fleet of aircraft employing lower technology weapons

in an effort to create mass. Mass of attack has been replaced by precision and stealth; both products of sophisticated technology. Modern aircraft and aircrew have a much greater survivability rate than World War II and this in itself is a significant saving to a nation. A comparative study of the cost-benefit analysis and efficiency of the application of lethal force between World War II and the current operations is not readily available in the unclassified domain. However, it would seem that 21st century air power is more cost-effective in the creation of 'unit effect', when considered in terms of resources expended and lives put at risk.

Asymmetric Aerial Threats Part I: Understanding The Concept (#343)

Key Points

- *Elements of air power have the capacity to be employed in an asymmetric manner to cause disproportionate damage and disruption at the strategic level.*
- *At the operational level UAVs have demonstrated the ability to 'fly under the radar' and defy some of the most sophisticated air defence systems of the world to accomplish mission objectives with a high degree of assurance of success.*
- *Asymmetric aerial threats created by the use of expendable UAVs have opened a new threat paradigm.*

The attack by a combination of drones and cruise missiles on 14 September 2019 on Saudi Arabian oil production facilities brought into focus the increasing danger posed to high value targets by asymmetric aerial threats at the sub-conventional level. These attacks resulted in a five per cent reduction in global oil supplies and an increase of nearly 20 per cent in oil prices across the world. The attack was a graphic demonstration of the capacity of elements of air power to be employed in an asymmetric manner to cause disproportionate damage and disruption at the strategic level. At the operational level it demonstrated the ability of the drones—uninhabited aerial vehicles (UAVs)—to 'fly under the radar' and defy some of the most sophisticated air defence systems of the world to accomplish mission objectives with a high degree of assurance of success.

Resorting to asymmetry in conflict is not a new concept and has been practised since the beginning of organised warfare. A militarily weak side relies on asymmetry to balance the unequal power equation with a conventional foe who has a preponderance of power. In recent years such entities are reaching out to cheap aerial capabilities to achieve greater asymmetry. It is certain that asymmetric

aerial threats are bound to proliferate with the easy availability of small and expendable UAVs, popularly called in the media 'drones'. The employment of these UAVs for a variety of purposes, especially in a suicidal mode, will become major threats to nations within and at the fringes of on-going insurgencies as well as irregular and civil wars.

Ivan Arreguin-Toft reviewed all irregular wars that were fought between the years 1800 and 2003 and published the results in a book titled *How the Weak Win Wars: A Theory of Asymmetric Conflict*, in December 2005. The analysis brought out some very interesting statistics. In all the conflicts reviewed, it was found that the stronger conventional forces won in 71.5 per cent of the conflicts, while the other 28.5 per cent was won by the so-called weak adversaries. This translates to the irregular forces having a one in four chance of emerging as the victor in the irregular war that they were fighting. The author went on to analyse further and demonstrated that when an irregular force resorted to the employment of optimised asymmetry, the chances of their success increased dramatically.

When these statistics were further sub-divided and analysed more critically, some improbable numbers came to the fore. It was seen that from the year 1800 to 1850 the stronger, conventional forces won the irregular war 88.2 per cent of the time. It was also seen that during this period the weaker adversaries were not adept at employing asymmetric means and used similar concepts of operations and tactics to the conventional forces. Obviously under these circumstances the preponderance of military power resident in conventional forces prevailed, rather easily.

The analysis of more contemporary conflicts, fought between the years 1950 and 2003 is more revealing. During this period the winning percentage of the stronger conventional forces dropped to a mere 48.8 per cent. In common words, this meant that the weaker irregular force employing asymmetric means and methodologies was more likely to win the conflict against a more powerful conventional force. While the current spread of irregular forces may not be aware of this statistic, their on-going activities indicate that they are aware of the trend. Further, asymmetry achieved through concepts such as the employment of improvised explosive devices and suicide-bombers have been effectively countered in the past decade or

so. The new *modus operandi* for irregular forces is aerial asymmetry created by the employment of expendable UAVs on suicide missions. A notable feature of this evolution is that the irregular forces are now stepping into a sphere of warfighting that has so far remained the exclusive purview of conventional forces. Arguably, air power has been the asymmetric advantage of conventional forces, which gets neutralised when the 'weaker' irregular adversary also leverages the characteristics of air power for their advantage.

Asymmetry is not a new concept and is unavoidable in conflict. It also is a matter of perception from the viewpoint of the analysing entity. For example, a conventional force would always consider sub-conventional operations as asymmetric, whereas an irregular force would consider such operations as standard and mainstream.

Asymmetry in the application of air power could be very broadly clubbed under three separate elements—asymmetry of technology, asymmetry of battlespace and asymmetry of concepts of operations. Asymmetry of technology is intimately connected to the asymmetry of force, i.e. of numbers and capability. An existing asymmetric advantage in technology can be deftly leveraged to neutralise numerically superior forces. Employing the asymmetry of the battlespace is a sophisticated concept and may not be possible for all irregular forces. Success in creating asymmetry in battlespaces requires the irregular forces to be able to retain the initiative as to the domain in which they want to operate and also the level—strategic, operational or tactical—in which they want to function. Asymmetry in the concepts of operations is more applicable to the employment of air power. The use of aircraft itself as a weapon system, like during the 11 September attacks on the twin towers in New York, is a classic example of such asymmetry.

Another asymmetric concept is the use of small and cheap UAVs to carryout indiscriminate and punitive aerial suicide-attacks on the general population that would gradually erode the 'will to fight', even if the targets are not of any value to the adversary. The practical difficulties in preventing such attacks and uncertainty regarding the next attack will invariably undermine morale.

Asymmetric aerial threats created by the use of expendable UAVs have opened a new threat paradigm. When this concept is combined with the emerging concept of 'swarming', high value targets—even deep inside a country with sufficient strategic depth—become vulnerable. With the maturing of this concept, air power is entering a new area of activity and becoming the power-element of choice to wage asymmetric war against a conventionally more powerful and entrenched adversary. At the operational level, the asymmetric employment of UAVs have ensured that they cannot anymore be considered an adjunct to mainstream air power systems—their tactical missions certainly create strategic outcomes.

Asymmetric Aerial Threats Part II: Threats and Responses (#345)

Key Points

- *Over the last three decades asymmetric aerial threats have become increasingly predominant in the battlespace.*
- *Asymmetric aerial threats can be classified as emanating from COTS devices and improvised weapons mounted on civilian airborne platforms.*
- *For conventional air power to succeed in irregular wars, especially when the adversary is adept at asymmetric warfare, it is necessary to establish a doctrinal foundation to its nuanced employment.*

Since the early 1990s, asymmetric threats have become increasingly predominant in the air domain, especially in the regions that are witnessing instability and irregular wars. Further, easy availability of affordable technology has transformed the battlespace into an evolving and complex morass that cannot easily be understood. Irregular adversaries have traditionally relied on sub-conventional threats mainly manifesting in the land domain and to a limited extent encompassing the maritime domain and littoral regions. However, the situation has now changed with even the air domain being subjected to the so-called non-traditional threats.

Air forces are the primary repositories of national air power and therefore have the primary responsibility to protect the nation from aerial threats, ensure the safety and security of its people, and guarantee the sovereignty of the nation. In the face of asymmetric aerial threats, conventional air forces will need to be agile in order to adapt and improvise to provide credible options to the government to neutralise these amorphous threats. From recent statistics, it is apparent that a 'weak' adversary employing asymmetric modus operandi have a slightly more than equal chance of achieving success in irregular conflict against a stronger but conventional

force. (See *Pathfinder*, Issue No 343, November 2019.) In fact, the further the irregular force can move away from the conventional, the better their chances of success. Conventional air forces will have to retain and reinforce their ability to create flexible and tailored responses rapidly across a broad spectrum of operations, if they are to be able to contain such threats.

Potentially, any aerial system, inhabited or otherwise, which has a reasonable range and payload carrying capacity, can now be employed as a weapon. The use of uninhabited aerial vehicles (UAVs), or drones, in the recent attack on Saudi Arabian oil production facilities is a stark demonstration of this new reality. Irregular forces have always avoided direct contact with conventional forces in the battlefield since their superior firepower would lead to unsustainable attrition for the irregular force.

Employment of asymmetry has been the preferred option of irregular forces. However, creating asymmetry in the air domain has so far not been easy for two fundamental reasons. First, aerial assets are resource intensive to acquire and operate and second, they are technologically advanced and therefore require specialised knowledge and training to operate, especially in a combatant mode against an adversary.

In the past two decades the situation has changed dramatically. UAVs have become affordable and, perhaps more importantly, openly available as commercial-off-the-shelf (COTS) items. Further, the functioning of COTS UAVs have been simplified enough for a person with the rudiments of a technologically-oriented education to operate them effectively. When combined with the open availability of explosive materials, they become attractive assets to implement asymmetric attacks on vital areas while bypassing the conventional fielded forces of a much more potent adversary. It is therefore not surprising that aerial asymmetry is gradually becoming more prevalent.

Asymmetric aerial threats can be classified as emanating from either COTS devices or improvised weapons mounted on civilian airborne platforms. COTS sensors such as radars, night vision or thermal devices mounted on general aviation platforms have been used in the past by irregular forces for intelligence, surveillance and reconnaissance (ISR).

Further, COTS drones have been used to disrupt the flow of normal air traffic, especially in airports with high volume of domestic and international flights, as was seen recently at Gatwick airport in December 2018. What may not be obvious is that such disruption can have cascading effects on the broader concept of national security that reach to the strategic level, which may not be immediately appreciated.

The second threat is the deliberate use of civilian aerial assets to deliver lethal payloads or improvised explosive devises. When this concept is adapted to the use of UAVs in a suicide mode, as a 'poor man's mssile', the effect can be catastrophic. The concern for the standard national security forces is the possibility of the employment of UAVs with chemical or biological weapon-grade payloads that could prove to be disastrous against vulnerable and open targets such as large crowds. Considering that the objective of irregular forces is to disrupt the normalcy of life, these activities could not only be devastating, but could also overwhelm the social services of the receiving nation. A combination of COTS drones carrying lethal payloads and being employed in suicidal missions could be considered an extremely high threat. Such a threat could be considered almost impossible to counter before the strike actually takes place, since they can avoid even the most sophisticated air defence systems that are designed to counter conventional aircraft and weapons.

A competent irregular force, faced with the prospect of being targeted by a conventional air force will be able to negate the classic doctrinal roles of air power that underpins its employment. It can be readily seen that control of the air and strike have almost no impact on the functioning of an irregular force and therefore they are not contested. Control of the air is conceded and the effectiveness of aerial strike is almost fully negated by the dispersed operational concepts that do not provide recognisable centres of gravity to target.

The effectiveness of conventional air power in irregular warfare is normally predicated on its ability to leverage off the inherent ISR capabilities and the nuanced use of air mobility. Air power now has the capacity to carryout long term surveillance from UAVs operating in the high altitude long endurance mode. Further, these UAVs are also capable

of carrying out precision strikes almost in real-time. Irregular forces tend to use their capabilities to influence and control 'ground' in an attempt to influence the local population. After all irregular wars are almost all about winning the approval and support of the population, which in turn is essential to winning political legitimacy and control. Conventional forces need to be deployed in order to counter this approach. Air mobility can ensure that a numerically small force is able to control and influence a disproportionately large area by airlifting small or large contingents rapidly to the area of interest.

For conventional air power to succeed in irregular wars, especially when the adversary is adept at asymmetric warfare, it is necessary to establish a doctrinal foundation to its nuanced employment against asymmetry. Asymmetric aerial threats are highly complex and countering them can never be considered a straight forward application of conventional air power at the lower end of the spectrum. It requires doctrinal clarity of a high order to adapt air power effectively to the irregular or sub-conventional level.

Asymmetric threats usually emanate from ideological theories transformed to physical threats with the idea of influencing and controlling the human mind. Irrespective of the technological sophistication of the conventional forces, the foundation for success will have to be laid in influencing the cognitive domain of the adversary. Air power is well suited for such a role, provided its exponents understand the nuances of its application across the spectrum of conflict and are able to scale up or down the capability as required, providing the Joint Force with alternative options. Employed effectively, air power can be a powerful capability enhancer for other domains.

Strike in the Era of Anti-Access/Area-Denial Postures (#348)

The past three decades have witnessed an evolving change in the air environment in the combat zones of the world. Before the Russian intervention in the Syrian War, the Western Air Forces—US and NATO countries—were able to operate unhindered by any credible opposition. The air environment was benign and did not need dedicated air superiority missions to acquire and maintain the necessary level of control of the air. With the induction of integrated air defence systems (IADS) into the Middle-East theatre of operations, the situation has indelibly altered. The changed circumstances have directly impacted on the capacity of air forces to deliver strikes, both kinetic and electronic, in order to create the desired effects.

The concept of denying unfettered access to adversary air power has now become a focus for belligerents who may not have a sizeable air force or the capacity to contest control of the air against the Western air forces. The concept of anti-access/area-denial (A2/AD) is based on preventing adversary access to specific regions (anti-access) and contesting the freedom of movement within that region (area-denial). A2/AD

Key Points

- *The induction of sophisticated IADS has directly impacted on the capacity of air forces to deliver strikes, both kinetic and electronic, in order to create the desired effects.*
- *The concept of anti-access/area-denial (A2/AD) is a dynamic expansion of the earlier 'point-defence' system, which creates a system of systems that is integrated into the larger air defence network of a nation and operates within a common operating picture.*
- *EW capabilities will be at the vanguard of the efforts to counter A2/AD postures by nations that face adversaries with overwhelming air power capabilities.*

is a dynamic expansion of the earlier 'point-defence' system that used to be attempted by the use of concentrated air defence systems, mainly anti-aircraft guns and short-range surface-to-air missiles (SAMs). The ground-based air defence systems that are in current use far surpass the limited capability of the older systems.

The modern systems attempt to create a defensive circle around a vital point or area by erecting a layered air defence system. High-altitude, long-range SAMs are combined with medium-range missiles and reinforced by combined short/medium range SAM/anti-aircraft artillery systems. Effectively the A2/AD system is actually a system of systems that is integrated into the larger air defence network of a nation that operates within a common operating picture. These developments create a complex and networked threat for the strike aircraft, necessitating a re-evaluation of the traditional suppression of air defence (SEAD) capability as well as the strike capability of an air force.

A keen understanding of the adversary's ground-based air defence system, its order of battle and doctrinal underpinnings have always been key to the success of SEAD and strike missions. This is an infallible truth, ever since strategic strike became an integral and critical part of air power projection in World War II. In modern times, the increasing effectiveness of IADS has made the gathering and dissemination of information regarding their capabilities a critical activity for the success of strike aircraft. This requirement will become fundamental and increase in its criticality as the quality and speed of data within the IADS avails of quantum improvements in radar and communications technology to create an increasingly complex and robust A2/AD capability. Nations are adopting A2/AD posturing since it forms a significant hurdle to an adversary with greater air power capabilities to deliver the desired effects against one's own critical vulnerabilities.

Historically, the basic SEAD mission was performed as kinetic strikes, which in turn sanitised a 'corridor' for the strike aircraft to carry out their mission without opposition, considering that control of the air would have been achieved. A classic example of the concept of a 'kinetic kill' is the

employment of the BAE Systems/MBDA Air Launched Anti-Radiation Missile (ALARM), which entered service during Operation Desert Storm in 1991 and was extensively used during that conflict. ALARM was a fire-and-forget missile that climbed to about 42,000 feet, loitered at that altitude using a parachute and monitored radio-frequency emissions from ground-based surveillance, intercept or fire control radars. When an emission was detected, the parachute would be discarded and the missile would home-in on the transmission with the help of a secondary rocket that was fired. By striking the target, even if the transmission was turned off, the missile achieved a kinetic kill.

The fighter aircraft-ALARM combination was efficient in neutralising localised air defences in a specific area and was effective for a predetermined period of time. Essentially it catered for a specific strike mission to achieve success by the kinetic destruction of critical elements of ground-based air defences. In combination with the campaign to achieve control of the air, this permitted strike aircraft to operate relatively freely with minimal air interference.

With the increased sophistication of IADS and the subtle change in the air defence concept towards enforcing A2/AD capabilities, it now becomes necessary to widen the horizon to facilitate important strike missions. Modern A2/AD concepts aim to focus capabilities to deny data exploitation, navigational and communication systems, and radar systems from surface, air, space and cyber domains. Countering such capabilities could pose a significantly more complex challenge than neutralising a localised air defence set-up. Such an IADS system of systems would require that cyber effects and electronic warfare, be supported by stand-off kinetic attack capabilities to effectively counter it. Benefits of adopting such a modern approach include the ability to create both kinetic and non-kinetic effects and in the case of the cyber domain, reversible effects.

Electronic attack capabilities will be at the vanguard of the efforts to counter A2/AD postures that are being adopted by most military forces, especially against what they perceive as adversaries with overwhelming air power capabilities. Electronic attack uses electromagnetic energy to

target enemy platforms, equipment and sub-systems, while electronic protection denies the adversary the ability to do the same to one's own systems. Since electronic warfare is gradually taking centre place in the overall strike capabilities of an air force, collection of electronic intelligence (ELINT) regarding hostile IADS has become crucial and indispensable for the successful prosecution of anti-A2/AD strike missions.

Air forces are also considering other concepts and approaches to defeating A2/AD postures. One aspirational concept is the possible use of the swarming technique, where large numbers of unmanned aircraft could be used to overwhelm an IADS at a chosen point. The swarm could also have genuine strike aircraft, either inhabited or uninhabited within it, which could then be employed to conduct electronic or kinetic strikes. Another futuristic technique being studied is cyber-attack that could inject malicious codes into the IADS network and using such disablement as an entry point into the broader network. Essentially, the concept development to counter IADS is evolving to look at options to deny its capability and operational effectiveness, either with a hard kill or through the electromagnetic spectrum.

Air strikes—kinetic or non-kinetic—that create the desired effects have become critical to the success of all military operations. With the introduction of sophisticated IADS into the battlefield and operationalising the A2/AD concept, the difficulty in successfully carrying out air strikes has increased greatly. By combining EW and kinetic strike in an optimum manner, air power can counter both these defensive activities. However, the cycle of countering offensive capabilities with defensive concepts and the further development of offensive ideas, will continue unabated.

Air Power in Support of Civil Authority (#349)

Key Points

- *It is probably realistic to state that air power essentially came of age during World War II.*
- *The Berlin Airlift at the end of World War II was an innovative use of air power capabilities to achieve a desired political end-state.*
- *Air power can provide aid to a civil authority through delivering humanitarian aid and disaster relief (HADR).*

From its inception as an element of national power projection capabilities, air power has proven to be one of the most flexible capabilities. In the initial stages of its development, post-World War I, the focus was on ensuring that its ability to overcome the barriers of terrain and 'fronts' could be adapted to further the operational military capabilities of a nation. Accordingly, technological developments were aligned to ensuring that air power would prove to be an equally important military capability, thereby introducing the third dimension—the air—into general warfare.

Air power capabilities improved by leaps and bounds in the inter-War period, assisted by concerted developmental efforts by scientists. Employment in the Spanish Civil War of the 1930s, while not creating a great deal of physical destruction, had a great impact on the morale of the civilian population. This conflict also saw the first inkling of the vexed debate that would forever dog air power regarding the ethical, moral and legal correctness of aerial bombardment. Even so, it is probably realistic to state that air power essentially came of age during World War II. Starting from the demonstration of the blitzkrieg operational tactics during the German invasion of Poland and the Low countries; its air-to-ground effectiveness in the deserts of North Africa; the fiercely fought Battle of Britain; the strategic Bomber Offensive in Europe; the firebombing of Tokyo; and culminating in the air dropping of two atomic bombs,

first over Hiroshima and then Nagasaki that provided a new meaning to the term 'catastrophic force', air power proved conclusively that it could be critical to victory. Even its detractors acknowledged that without air power, the status quo might be maintained with considerable effort, but victory may often not be possible.

Two major developments in capability, as well as tactical innovations in the employment of air power during World War II, have not been given the importance they deserve since in the long-term they proved to be the stepping stones to the evolution of more sophisticated methods for the application of air power. Both of these developments involve the revolutionary use of cargo carrying aircraft to further the achievement of military objectives. First, was the concept of dropping army soldiers into the battlefield or behind the enemy lines from aircraft to carry out predetermined tasks—the origin of the paratroopers, as they are known today. This concept was slightly modified with great success by General Ord Wingate to conduct his famous Chindit Raids in the jungles of Burma against the Japanese Army. In this adaptation, the soldiers were supplied and sustained from the air for long periods of time while they operated with great effect behind enemy lines.

The second development came immediately after end of World War II. When the stand-off between the Western powers and the Soviet Union came to a head and threatened the people of Berlin with starvation, essentials were supplied to them from the air in what came to be known as the Berlin Airlift. This operation demonstrated a hitherto unexplored capability of air power—the air supply of essentials to a civilian population in need of support rapidly conducted over relatively large distances. From this emerged the modern concept of air power delivering aid to a civil authority when required.

In the contemporary concept, 'aid to civil authority' is an all-encompassing term and covers all alternative operations that air power undertakes other than the threat or the actual application of force, through operational actions in combat zones or the provision of support to other military operations.

The dearth of inter-state conflict in most parts of the world today has brought in a situation wherein only a few air forces are involved in irregular wars of different hues. There are also some air forces involved in domestic, or internal security duties, especially in Latin America. Analysing the trend in the employment of kinetic air power elements in the past three decades, and then drawing a possible future trajectory, emphasises the point that modern air forces need to maintain minimal deterrent capabilities to meet the potential threats to the nation. In most cases this would amount to a re-evaluation of the combat capabilities of the force, which are by far the most resource-intensive to acquire, maintain and operate.

The result of this gradual reduction in the use of the warfighting capabilities of air forces and air power is that most air forces are examining the potential to alter the force structure of their forces to cater for a new paradigm in delivering humanitarian aid and disaster relief (HADR). This is not to suggest that there has been a shift in the priorities of an air force—fundamentally they exist to project military power or influence through the control and exploitation of the air domain to achieve strategic, operational or tactical objectives jointly in a multi-domain environment. To achieve these objectives, a minimum quantum of sophisticated combat capabilities have to be resident in the force. The re-orientation of the force structure should cater for this requirement as a fundamental and unalterable fact.

The need thereafter is to consider the other elements of air power that support a civil authority—in delivering HADR when required, providing rapid medical evacuation from disaster-hit regions, search and rescue operations, fire-fighting, and transporting people from natural disaster and war zones. In conducting such operations, multi-functional military transport aircraft and helicopters have a great advantage over their civil counterparts that are normally configured for a single role, most of the time on a semi-permanent basis.

While there is no doubt that the employment of air power to provide HADR and other support services to a civil authority enhances the response options available to the government in times of natural

calamities or other emergencies, the same capability can be employed to assist neighbouring and other friendly countries in times of need. Such employment of air power assets would enhance the diplomatic endeavours to maintain close and supportive relationships with other nations and would prove to have an effective long-term strategic effect. While air power is a sophisticated deterrent element at the high-end of military capabilities, its utility across the entire spectrum—from cooperation to conflict—has a critical role to play in contributing to the stability of our region.

New Thinking to Solve Old Challenges: The Link Between National Security, ADF and the Liquid Energy Market (#350)

Key Points

- *Liquid energy security is a critical element of the national security portfolio.*
- *The ADF holds one of the largest shares of the liquid energy market held by a single operator.*
- *The ADF adopting a single grade of fuel creates an opportunity that could minimise the risks associated with Australia's liquid fuel security by creating demand for fuels produced via the FT process using Australian natural resources.*

In 1939 the Heinkel He 178 became the first aircraft to be successfully powered by a turbojet engine. The inventor, Dr Hans Von Ohain of Germany, chose gasoline as its fuel because it was widely available and was used in all piston engine aircraft. Similarly in 1941, Sir Frank Whittle of Great Britain used illuminating kerosene for his turbojet, again because it was widely available; an early indication that turbojet engines might prove more tolerant of a wider range of fuel types than piston engines. In these early years of development therefore, jet fuel properties were primarily dictated by fuel system constraints, operational requirements and, ultimately, by availability.

The first provisional jet fuel specifications were published in 1943 in England and 1944 in the USA. As engines and specifications developed, it became apparent that fuel properties such as freeze point and higher volatility were key to defining jet fuel characteristics. Jet fuels have accordingly evolved into the most regulated transportation fuels with an extensive set of specifications. In turn, this has led to increased dependence and demand for crude oil. For example, Australia is heavily dependent on imports, a situation that shows no sign of changing in the immediate future. Importantly, the dependence on oil imports leaves Australia exposed to global events, such as the 13 September 2019

drone attacks in Saudi Arabia, which led to a 13 percent increase in fuel prices. Similarly, the impact of the COVID-19 global crisis on the supply of liquid fuel into Australia cannot be predicted. While the Australian government might leave its ports open for the delivery of liquid fuel into the country, the liquid fuel supply chain will be adversely affected if the delivery of oil ceases.

In April 2019, the Department of the Environment and Energy released its interim report titled *Liquid Fuel Security Review.* The report recognises the complexities of the liquid fuel market and suggests that while supply shortages have potentially high consequences for Australia, threats to fuel security have a low likelihood of occurring with the core assumption of uninterrupted supply through the Indo-Pacific. Recent events such as Queensland closing its ports to foreign vessels suggests a weak foundation for such an assumption.

In contrast, in his 2018 Australian Defence Magazine article, former Deputy Chief of Air Force John Blackburn aptly highlights that the Government's market-based focus attempts to shift responsibility to the industry. Given the events in Saudi Arabia and the ongoing COVID-19 pandemic, liquid fuel security is a national security concern. It is of direct consequence to the ADF's ability to raise, train, sustain and project the joint forces to create the necessary effects. Leaving this critical element of national security to the market places existing liquid fuel security policy at risk, potentially affecting the ADF's ability to deliver desired outcomes when necessary.

Akin to the rest of Australia, the ADF is reliant on liquid fuel supply. Fuel is ADF's largest single commodity expenditure, amounting in 2016-2017 to 423 million litres of fuel, costing approximately A$423 million. The Air Force consumes about 70 percent of the total, followed by the Navy. These figures place the ADF as one of the single largest liquid fuel users in Australia, providing substantial leverage in influencing the liquid fuel market. This situation is complicated by the ADF requiring seven different grades of liquid fuel. Take for instance, NATO grade *F-44*, a commercially produced high flash point aviation fuel. This has

been difficult to procure due to the low volumes required, which raises the cost of production to a point where refiners refuse to produce it.

Conceptually, the military uses commercial fuels containing additives that cater for the ADF's diverse operational conditions and to cater for its materiel, which could be brand new or relatively old. The military specification fuels are *F-34*, *F-44* and *F-76* which are commercially produced *Jet A1*, aviation carrier turbine fuel for ship borne operations and commercial diesel fuel. Following production, the military additives—*Static Dissipating Additive*, *Corrosion Inhibitor/ Lubricity Improver* and *Fuel System Icing Inhibitor*—are added prior to delivery to the ADF. Traditionally, due to their high flash point, ships and ship borne aircraft use *F-76* and *F-44* respectively. *F-34*, with a lower flash point is used by land-based air assets and has a lower cost of production.

F-44 is the most stringently produced fuel and it meets and often exceeds the performance characteristics of all the other fuels listed earlier. Hence, it can be used on *all* Defence assets equipped with a gas turbine or a diesel engine without deleterious effects. For example, an MRH 90 helicopter can operate using *Jet A*, *Jet A1*, *F-34* and *F-44*. When the MRH 90 operates with the RAN it switches from *F-34* to *F-44* as needed. Similarly, a Sea Hawk helicopter can take off from a ship with *F-44* on board and in transit can refuel with *F-34* at RAAF Richmond *en route* to another location. Furthermore, because of its properties, the practice of blending *F-44* with commercial diesel fuel and *F-76* occurs routinely to power ships. Furthermore, *F-44* is used as emergency back-up for US Navy nuclear submarine diesel engines. Finally, Australian M1A1 tanks can use any of these grades of fuel in their gas turbine engines. In very cold regions they can swap from *diesel/F-76* to *F-34/F-44* due to their much lower freezing points. It seems then, there is merit in investigating the possibility of using *F-44* in lieu of *Jet A*, *Jet A1* and *F-34* for aircraft, and in lieu of commercial Diesel fuel and *F-76* for ships, submarines and tanks. Accordingly, by combining the total fuel requirement into a single grade of fuel, the

ADF can achieve economy of scale to shape the liquid fuel market in Australia.

With the above in mind, using Australian resources to produce jet fuel creates an opportunity that can solve Australia's fuel import dependency. In this context, the Fischer-Tropsch (FT) refining process – which is used to convert coal and natural gas into liquid fuels – is a prime example. The FT process was invented by the Germans in World War II and improved by South Africa during apartheid. More recently, the FT process has been commercially used by Qatar and South Africa to supplement existing liquid fuel exports. Hence, harnessing Australia's mining industries to create liquid energy security without any negative impact to its economy through the FT process is an attractive proposal. Furthermore, depending on the production method, fuels produced via the FT process create lower greenhouse gases than their traditional counterparts delivering positive environmental outcomes.

The possibility of using fuels manufactured via the FT process that uses Australia's already well-established mining industry, coupled with the economic advantages of the ADF adopting a single grade of fuel creates an opportunity that could minimise the risks associated with Australia's liquid fuel security. Specifically, the Government could work with industry to develop an indigenous fuel manufacturing capability based on existing natural resources (coal and natural gas) and the FT process. This initiative is low-risk because industrial application of the FT process is a well-established procedure. Furthermore, it leverages Australia's significant coal and gas industries for domestic consumption and isolates exposure to foreign supply chains. Finally, depending on the methods chosen, positive environmental protection outcomes can be achieved with the FT process.

The Enduring Enigma Of Air Power (#351)

Key Points

- *World War I provided an impetus that accelerated the induction of air power as an element of military power.*
- *The operational induction of precision weapons in combination with stealth technology ushered in a new era of air power employment.*
- *The enhancement in air power capabilities had a significant and surprising influence on international political developments.*

Air power has been employed as an instrument of national power for more than a century. It has, without doubt, become integral to the conduct of modern warfare, at times becoming its central element, especially in the past few decades. Air power is vast in its spread, encompassing all uses of aviation in the pursuit of national power and security imperatives.

Although aviation, as we know it today, was barely in the first decade of its development, World War I provided the impetus that accelerated the induction of air power as an element of military power. From this somewhat humble beginning as an adjunct to the surface operations of World War I, the evolution of air power and the concepts of its employment continued unabated over the next century at a pace that had not been witnessed in the case of any other previous power projection capability. These developments were driven by innovations in technologies and sciences such as aerodynamics, metallurgy, propulsion, air-delivered weapons, radio, electronics and others. The innovations also were made necessary by the security concerns of the major world powers and the policy decisions that were made regarding national security and national interests.

Post-World War II, the emphasis was on strategic bombing, primarily brought about by the national security strategy of 'Massive Retaliation' adopted by the USA under President Eisenhower's administration.

However, simultaneously, there was understanding that in World War II, conventional strategic bombing had failed to produce the promised decisive and rapid results. Gradually the belief that nuclear war was not a viable option—because of the mutual-assured destruction that such a war promised—came to dominate the conceptual thinking regarding the employment of air power. Not long after, strategic bombing as the primary role for air power was pushed to the background.

The strategy of 'Flexible Response' that was espoused by the USA in the early 1960s gave a further fillip to the concepts of employment for conventional air power. The Vietnam War became the proving ground for a number of concepts of employment of air power, almost all of them pointing the way for this dynamic capability to become entrenched in joint operations—enhancing firepower and achieving the desired objectives at the tactical and operational levels far more easily than without the participation/availability of air power.

The operational induction of precision weapons in combination with stealth technology ushered in a new era of air power employment, denoting a step-change in air power capabilities, employment and its effectiveness. Precision-guided munitions (PGMs) were conceived for employment against static targets in an urban landscape and against fixed military installations, in order to avoid unnecessary and avoidable collateral damage. However, true to its fundamental characteristic of flexibility, air power adapted its employment envelope to optimise an aircraft's ability to target deployed military forces—whether moving or static, entrenched or in the open, day or night and even during inclement weather—to increase the efficacy of air power and create the desired effects on the battlefield. The only additional requirement for this concept to become entrenched within the application of air power was to ensure that adequate detection and identification capabilities existed within the broader air power capability spectrum of a force.

This 'secondary', adapted use of PGMs fundamentally changed the relationship between land and air power at the operational level. The focused efficacy in the application of air power brought about a tacit acceptance that in a joint military operation, any of the domain-centric

elements could be the supporting or the supported ones and also that the emphasis could change in a contextual manner.

Perhaps more importantly, this enhancement in air power capabilities and its dove-tailing as a critical element within a joint campaign had a significant and surprising influence on international political developments. First, PGMs and stealth technology are at the high-end of the technology spectrum and therefore not only expensive, but also have limited availability. Therefore the fielding of a PGM-stealth combination in any meaningful manner will have an associated cost-escalation factor to it, which will have a direct bearing on the power projection capability of a nation. Second, the first real demonstration of the effectiveness of the PGM-stealth combination came during the 1991 Iraq War, which coincided with the initial stages of the collapse of the erstwhile USSR.

Even a cursory analysis of the cost-escalation in adopting the PGM-stealth combination and the fortuitous timing of the demonstration of its effectiveness in the Iraq War, indicate the influence that it brought to bear in thrusting the United States as a globally preponderant military power in the post-Cold War world. The role played by high-end air power, epitomised in the PGM-stealth combination, and its influence in strategic decision-making is not well-understood and/or documented accurately.

The other factor, once again underplayed, that makes air power an enigmatic element of power projection is that combat air power and its dedicated application in high-intensity air campaigns are only one and at times a minor part of holistic air power capabilities. The 'other' air power capabilities; airlift, air-to-air refuelling, command and control, intelligence, surveillance and reconnaissance, communications, and air bases; are not only critical to the generation, application and sustainment of air power, but are also needed to ensure that air power creates strategic effects. In fact these air power capabilities sometimes go unnoticed and their contribution to national security imperatives are not well-understood. Air power, with its non-lethal capabilities has the ability to create rapid and decisive effects at the strategic level, which in turn provides the Government multiple options to achieve desired end-states across the full spectrum of International Relations, from cooperation to

conflict. In short, while often considered 'enabling capabilities' in support of a kinetic 'main' effect, it is frequently the case that non-lethal air and space power effects *are* the ones that create the main effect. In the contemporary strategic environment of constant competition, typified by malign actors' exploitation of the 'grey zone' – below the threshold of declared conflict – these capabilities are critical to Government's ability to respond through relationship and capacity building.

The unique characteristics of air power, its ability to create the desired effects at the strategic level very rapidly, and its on-going evolution in terms of technology and concepts of operations have made it a critical element of national power. The important fact here is the on-going innovations that are taking place in the capability development sphere of air power. Through the development of evolutionary doctrine, for the past century, air power has continually moved forward, adapting to changed circumstances, flexibly catering to rapidly altering threat scenarios, and demonstrating its ability to function simultaneously at the tactical, operational and strategic level of ensuring national security. This remains the enduring enigma of air power.

Air Power in Effects-Based Warfare Part I: Historical Background (#352)

Key Points

- *Technological advances in air power in the second half of the 20th century made it possible to strike and/or neutralise the centres of gravity.*
- *As early as 1916, achieving air superiority had become the core effect necessary to ensure success in the surface battle.*
- *The conduct of an effects-based campaign during World War II required the identification of the correct target set/ system in order to generate the necessary effect.*

Warfare waged from the air has now been a fact for just over a century. From the early days of air power being employed as an instrument of military power, airmen have made attempts to measure the effect that their actions have had on the adversary and then to connect these effects to the success of the operations being undertaken. Viewed from this perspective it becomes apparent that effects-based warfare is not really a new concept as such.

Since the conduct and characteristics of war is continually evolving, and has been over the centuries, the concept of effects-based warfare has also evolved. On the other hand, not unexpectedly, the nature of war has remained unchanged in its pursuit of the desired political end-state, the accompanying violence and brutality, and in its unpredictability. In the factors that influence its evolution as well as its steadfast constancy in its nature, another factor has remained with absolutely no change—war is a human activity.

In the second half of the 20th century, modern technology enabled a revolution in military affairs that influenced the international strategic environment. This revolution brought about the ability to create highly enhanced situational awareness. Perhaps more importantly, it enabled

a military force to predict, with a much higher level of assurance than before, the adversary's probable actions and reactions to an emerging situation. In turn, the same technological advances made it possible to strike and/or neutralise the centres of gravity of an adversary. Air power heralded the assurance of precision, discrimination and proportionality to these offensive actions.

From the beginning of its employment as a military power projection instrument, air power has strived to create and sustain the effects necessary to subdue the adversary and ensure that no action inimical to one's own interests are initiated by them. Air power has journeyed for the past century with this cardinal principle at the core of its conceptual development and employment.

Even before the outbreak of World War I and the induction of air power into the military triumvirate, its effect on the conduct of war was well-understood, at least by military professionals. The earliest were the effects created by balloons, which provided a 'live' and wider perspective of the battlefield either through direct observation or aerial photography. These observations provided the inputs necessary to improve the accuracy of artillery fire on the adversary. Essentially, as Lord Wellington put it, it gave the land forces the ability to see 'the other side of the hill'. By 1911, the Italians had 'air-bombed' Libya and although the damage done was miniscule, it was reported to have created a 'dramatic' effect on the adversary.

During World War I, as early as 1916 in Verdun, both the opposing militaries realised the criticality of having to obtain and maintain air superiority to achieving overall victory. Air superiority was required to have the freedom to carryout air reconnaissance that in turn facilitated accurate artillery fire in support of the infantry manoeuvres. Achieving air superiority had become the core effect necessary to ensure success in the surface battle. Effects-based application of air power—even though not termed as such—had become a reality. By 1918, when World War I came to an end, all the roles and missions that air power undertakes to this day had been attempted and their effect on the conduct of war was already being studied.

In 1917, the Zeppelin raids on London created what was perhaps an unintended effect. Even though the damage inflicted by the raids was insignificant, they led to the institution of the Smuts Committee and the subsequent formation of the Royal Air Force in 1918, the first independent air force in the world. The most important strategic effect created by the advent of air power as a military force in World War I was the acceptance of the concept of total war. This development was a classic case of operational effects creating strategic repercussions. During World War I, air power very clearly demonstrated that it could transcend land boundaries and thereby attack the adversary homeland, if so desired. The battle of fronts, as practised until then by the surface forces had been converted to one of areas, that could be chosen at will by the application of air power. Further, with the development and introduction of four-engine bombers into the air power calculus, the concept of 'taking the fight to the enemy' took on a new meaning.

The large bombers were introduced towards the very end of the War and therefore their impact on the conflict was minimal. Even so, the major lesson that was derived from their employment was the profound effect that the idea of 'strategic bombing' had on air power thinking and conceptual development. The other significant air power development that crystallised at the end of World War I was the emergence of the clear connection that had to be established between technological developments, tactical requirements and concepts of employment in order to create the necessary effect to achieve the desired military and political objectives. This trend has been enduring in air power development and doctrine since then.

Taking off from the concept of total war, in World War II, the quest for creating strategic effects—buttressed by the belief that air power could bomb a people/nation into submission—became intertwined with the Strategic Bomber Offensive against Germany. The less than optimum results of this campaign somewhat diffused the focus that air power had so far maintained on conducting effects-based campaigns.

Despite the diffusion in the creation of effects through strategic bombing, the employment of air power throughout World War II in

terms of conducting effects-based campaigns had a common conceptual thread. It highlighted the need to identify the correct target set/system to be neutralised in order to generate the effect that was required to achieve the desired objective. Further, it was also realised that the ability to find, fix and hit the selected target was equally important to create the necessary effect. From 1942 onwards the two requirements were merged, which was the start of the development of effects-based targeting and the subsequent search for the centres of gravity of the adversary.

These operational requirements that emanated in World War II led, even as the War was being fought, to a concerted effort at a combined tactical and technical innovation level that refined air operations in such a way as to dovetail it into an enduring form of operational art and strategy.

Air Power in Effects-Based Warfare Part II: Evolving Application (#353)

Key Points

- *The Berlin Airlift remains a classic example of the employment of non-lethal air power capabilities to create strategic effect.*
- *In 1989, the publication of John Warden's path-breaking appreciation of air warfare in his book The Air Campaign brought effects-based thinking and conceptualisation back into mainstream air power thinking.*
- *Air power's inherent characteristics of speed, range and flexibility combine to create an unmatched rapidity of response to emerging calamities and makes it the first response in HADR.*

At the end of World War II in Europe, the allies split into the Western democracies and the Communist bloc. Within a couple of years after the armistice, air power was called upon to undertake an entirely different kind of effects-based campaign than the application of lethal force. The Soviets had overrun the territories around Berlin and blockaded the Western nations from entering parts of Berlin that they controlled, in an effort to annex the entire city. Berlin was an island surrounded by Soviet occupied states with the Allied states many kilometres to the west.

The initial blockade started on 1 April 1948 and by 22 June all barge, rail and road traffic to West Berlin had been stopped. The blockade was supported by 30 full-strength Red Army Divisions (amounting to nearly 400,000 troops) and a capable tactical Air Force element. At the outset, it seemed only two options—fight or flight—were available to the West. A third soon emerged however: the supply of West Berlin from the air. It was decided to aerial supply West Berlin until the issue could be diplomatically resolved. Airlift of essential supplies started on 26 June 1948 and, although the blockade was officially lifted on 12 May 1949,

continued till 30 September 1949. By this time a staggering 275,000 airlift sorties had been flown, which delivered 2,325,000 tons of supplies. The Berlin Airlift remains a classic example of the employment of non-lethal air power capabilities to create strategic effect.

At the end of the War, the concept of creating 'desired effects' through the application of air power was studied in detail. The analysis indicated that normally damage assessment was realistic. However, in order to assess the 'effects' created, it was necessary to first determine 'what the enemy held most dear', or the object which, when destroyed, would create the maximum impact. Namely, the centres of gravity of the adversary. Even today, when close to perfect situational awareness and near-real time information dominance has become the norm, planners must be aware of the limitation in identifying the centres of gravity while conducting an effects-based air campaign as part of the Joint Campaign.

The immediate post-World War II era was the real beginning of conceptualising effects-based warfare. However, the inordinate losses suffered by the bomber fleet created a secondary effect on the development of air power—any technological development that was aimed at reducing the risk to aircrew was snapped up and employed. The mindset towards trying to achieve nil rate of own casualties thus became entrenched, especially in Western air forces.

The development of effects-based concepts of operations suffered a setback during the era of nuclear détente, which exemplified the Cold War orthodoxy. For nearly three decades hardly any development took place to further this concept in the arena of air warfare. This period also saw the stultification of air power doctrine in most air forces, with doctrine becoming subsidiary to equipment replacement imperatives. Forward-looking operational planning and the holistic concept development needed to move the effects-based approach fell by the wayside.

It was only in 1989, with the publication of John Warden's path-breaking appreciation of air warfare in his book *The Air Campaign* that effects-based thinking and conceptualisation came back into

mainstream air power thinking. His theory crystallised the nucleus of effects-based warfare from an air power perspective. 'Warden's Rings' used to prioritise the target systems, epitomised the concept of effects-based warfare at the operational level—ably demonstrated in the Iraq War of 1991.

During the build-up to the War in 1991, perhaps for the first time after the Berlin Airlift, air mobility once again established its ability to rapidly create strategic effect. In support of Kuwait and Saudi Arabia, a US-led military alliance, sanctioned by the United Nations, assembled in record time in the deserts of the Middle-East against the intransigence of Saddam Hussein, the Iraqi dictator. This was a clear demonstration of the efficacy of the application of non-combat air power capabilities in creating strategic effects to support national security imperatives. The 1991 Iraq War also validated the ability of combat air power to deploy across long distances, if adequately supported by air-to-air refuelling capabilities. The concept 'taking the fight to the enemy' was taken to a very different level of proficiency and acquired a new meaning. Both these actions, created effects at the strategic level of campaign planning.

The 1991 War also demonstrated the need to have complete control of the air to carry out any other meaningful action. This imperative was clearly indicated in the prioritisation of targets that was done to create the necessary effects—the command and control nodes of Iraq's air defence systems were the priority targets at the beginning of the war. The dependency of air power on the support elements—electronic warfare, suppression of enemy air defences, intelligence, surveillance and reconnaissance, air-to-air refuelling, airborne command and control elements—became validated. The need to have the entire package to create the necessary effects became the accepted 'Western way or war'. Subsequent to the war, the creation of non-kinetic effects also became the centrepiece of some of the campaigns, retaining equal importance at the operational level.

While the force projection packages were being fine-tuned and made into formidable capabilities to pursue effects-based warfare, another less studied employment of air power was also moving ahead

and becoming increasingly important. From the 1960s, rotary wing aviation and its employment in both war and peace have created effects at all three levels of war. While the utility of helicopters in times of conflict have been fairly well documented, their contribution to the more benign aspects, casualty evacuation and utilisation in search and rescue missions have been underrated. These missions have become integrated to helicopter operations across the full spread of the spectrum of conflict.

Similarly, the delivery of humanitarian aid and disaster relief (HADR) by transport aircraft has become somewhat common place and creates a strategic effect far greater than the actual tonnage of the load that is carried. As advanced information technology has virtually shrunk the world, global awareness of disasters, both natural and human-generated, have become much more acute than even two decades ago. The provision of aid to people in distress has become a duty and a responsibility of nations in better shape. It also creates a positive effect in terms of improving relations between the donor and recipient nations. Air power has come into its own in the HADR role. Its inherent characteristics of speed, range and flexibility combine to create an unmatched rapidity of response to emerging calamities, which makes it the first-choice option for the provision of HADR. The effect is not only immediate, but has far-reaching strategic consequences.

Air power has the versatility to create effects, kinetic and lethal, as well as non-kinetic and benign, being two sides of the same coin. It is this versatility that makes air power a critical capability within the full spectrum of effects-based warfare.

Air Power in Effects-Based Warfare Part III: Challenges to Effectiveness (#354)

Key Points

- *Effects-based warfare is essentially joint in nature.*
- *The conduct of effects-based warfare is complicated because it is difficult to determine and quantify the actual effect and its impact on adversary behaviour.*
- *A coalition campaign adopting an effects-based strategy may not be able to create the critical effects necessary to achieve the desired end-state in an optimum manner.*

Air power's inherent characteristics of range, rapid response and the focused weight of attack that could be brought to bear made it ideal for employment in effects-based warfare. The concept of operations developed for effects-based warfare in the late 1980s were brought to a culmination in the Gulf War of 1991. Although the air campaign in this war was touted as an absolute success and a blueprint for future campaigns, air power faced few challenges in fully exploiting the concept of effects-based warfare. It was also noticed that there was a distinct gap between the ends-ways-means equation and the implementation of the refreshing concept that had been developed.

Effects-based warfare abounds in command and control (C2) challenges, at all levels of command and warfare. Effects-based warfare is essentially joint in nature, since the effects to be created need the judicious application of all elements of the military force. This effort will have to transcend and align with a whole-of-government approach to containing the adversary. Such an integrated approach is considered necessary to contain emerging and complex threats to national security.

Centralised control and decentralised execution has long been accepted as the basic tenet that determines the C2 arrangements of an air campaign. However, in pursuing an effects-based concept of operations, this tenet may be difficult to achieve, especially when the force is the

air element of a coalition, functioning within the bounds of a multi-national alliance. The tenet of C2 has been somewhat modified in recent times—at least in some advanced air forces—to centralised command, distributed control and decentralised execution. This is a more nuanced way of enacting C2 on the air elements functioning within a coalition. The assurance of creating the necessary effects reduces with the reduction in the effectiveness of C2.

Selection of targets, which when neutralised would create the desired effects, is another aspect of effects-based warfare that is a complex process. Neutralisation of a target can create direct effects; primarily in one of the three levels of conflict—strategic, operational and/or tactical. However, direct effects are invariably followed by indirect and cascading effects, which are unpredictable. Targeting is complicated because the indirect effects tend to impinge both on the higher and lower levels from where the direct effect has impacted. In simple terms, even when target selection is appropriate to create the desired effect, the secondary effects of the action cannot be predicted with any level of assurance. This conundrum encapsulates the complexity of adopting an effects-based warfare concept—the desired direct effect of prosecuting a selected target does not provide any indication of the range of possible causal consequences of neutralising that target.

An associated challenge is in measuring the effect that has been created by one's own actions. The expected effect on the adversary is not always easily discernible. Complicating matters further is the difficulty in determining the actual effect and its impact on adversary behaviour in a clear and quantifiable manner. Air power can minimise these intractable challenges by ensuring that assessment obtained through the fusion of mission debrief, tactical air reconnaissance, signals intelligence, satellite imagery and human intelligence is fed back into the target selection and operational planning processes. Success in effects-based warfare requires the commander to have a clear strategic view of effects created and their impact—achieved only through the seamless fusion of C2, assessment feedback and operational planning.

The air campaign of Gulf War 1991 could be considered a path-breaking effort that generally adhered to the central tenet of air C2, based loosely on Warden's Rings. However, practical challenges detracted

from air power realising its full potential in effects-based warfare; the sheer weight of air effort over the initial 39 days of the war was equally important in air power assuming a decisive role in the success of the war. Immediately following this war, the air campaign over Bosnia—Operation *Deny Flight*—demonstrated all the challenges in achieving efficient and centralised C2 in the conduct of coalition air campaigns. Operation *Deliberate Force* of 1995, could be considered the coming of age in conducting a successful air campaign within the construct of effects-based warfare, even though air power operated under some extreme constraints. Success stemmed from correct target selection to create carefully considered strategic, operational and tactical effects.

At the turn of the century, analysts had started to look afresh at the 1991 Gulf War and the campaigns that followed in the next decade. It was realised that in all these cases the effect that was being sought to be created was one of denial—in the Gulf War the stated aim was to deny the Iraqi Air Force the freedom of action necessary to intervene in ground operations; and in the Balkans to deny the Yugoslavian Air Force the ability to interfere with NATO operations. The transition to full-fledged effects-based warfare during these campaigns had not taken into account the 'what ifs' of operating in a contested airspace when the operating situation would change. The effects to be created to ensure that adequate control of the air could be achieved had not been any considered.

Although the concept was well understood at the strategic theoretical level, the campaigns that followed the 1991 Gulf War brought to light another challenge to the practical application of the concept. The security interests of the individual nations in a coalition always influenced the appreciation of the desired end-state and therefore would shade the effect to be created. Under these circumstances, the validity of target selection became open to question and debate. At the strategic political level it became apparent that the cohesiveness of coalition operations itself was a function of the commonality of understanding and acceptance of the effect to be created. The salutary lesson that emerged from the campaigns of the 1990s was that in a campaign adopting an effects-based strategy, coalition operations may not be able to create the critical effects necessary to achieve the desired end-state in an optimum manner.

It also emerged that effects-based warfare was almost totally dependent on rapid and timely decision-making at all levels of war. If this fundamental requirement could not be met, the concept was bound to fail, as repeatedly demonstrated in the campaigns of the 1990s. The air campaign in effects-based warfare, envisaged as a sudden downpour that would deluge the adversary, will not be successful if air power is applied as an intermittent drizzle that hardly drenches the opposition.

As a result, the concept of 'time-sensitive-targeting' came into vogue in the late 1990s in an attempt to shorten the time between spotting a target and prosecuting it successfully—tacit acceptance of the crucial need for clarity in C2 arrangements to ensure efficacy in effects-based warfare.

As much as air power capabilities have become focused, moving from being a sledge hammer in World War II to the finely tuned rapier of today, a higher strategic level of control determines its effectiveness, especially in effects-based warfare. Friction within the C2 process and in delegation will always be detrimental to pursuing effects-based warfare. The focus on effects-based warfare from the early 1990s highlighted the inevitable friction in the C2 process and the resulting inefficiencies when multi-national campaigns are undertaken, which perhaps exceeds the benefit of political legitimacy that the multi-nationality of coalition forces provide.

Air Power In Effects-Based Warfare Part IV: Demonstrating Operational Decisiveness (#355)

Key Points

- *By the turn of the century, the concept of effects-based warfare had been clearly validated.*
- *In the 2003 Iraq War, accurate air strikes ensured the continued momentum of the ground offensive and was critical to the success of individual encounters, battles and the overall campaign.*
- *A detailed understanding of the culture, ethos and myriad other intangible factors influencing the adversary is fundamental to understanding the effect.*

The application of air power within multi-national air campaigns was sometimes flawed because of the friction created by the need to satisfy overriding political factors of different nations to ensure the minimum required cohesion of the coalition. Even so, by the turn of the century, the concept of effects-based warfare had been clearly validated. During the decade after the 1991 Gulf War, the imposition of the no-fly zone over Iraq both necessitated and facilitated the introduction of new weapon systems and associated tactics and techniques in order to ensure that the desired effects could be achieved.

The employment of air power changed when Operation *Enduring Freedom* was mounted against the Taliban regime in Afghanistan post the events of 11 September 2001. In Afghanistan, given the agrarian society, there were no target systems in the context of Warden's Rings, which air power could prosecute to create the necessary effects to defeat the Taliban. After a quarter of a century of continuous war that had led to the destruction of its infrastructure, Afghanistan was devoid of any fixed target systems to be attacked from the air. Further, the Taliban did not possess even rudimentary air

power capabilities and had no recognisable air defence assets. However, within a few short weeks of the commencement of the operations, true to its inherent flexibility, air power became a decisive element in Special Forces operations—providing accurate and near real-time fire support. This concept evolved and placed air power as the primary strike element facilitated by Special Forces nomination of targets. Such air strikes had a devastating effect on the morale and fighting ability of the Taliban forces.

After the Taliban regime had collapsed and the onset of winter denied opportunities for concerted ground operations, air power again adapted an old strategy practised by the Royal Air Force in the 1920s in the Middle-East—of punishment from the air. The new phase culminated in the bomber attacks on the Tora-Bora mountain ranges in East Afghanistan. The effect achieved surpassed all calculated expectations and was decisive in pushing the Taliban on the back foot at the operational level.

The air campaign that was part of the 2003 invasion of Iraq was perhaps the first to have been created in pursuit of an effects-based strategy from the very beginning. This move was facilitated by the fact that the coalition had only a few nations who had been long-term partners. The interoperability and commonality of technology shared by these nations facilitated increased operational efficiency. More importantly, a new 'way of war' emerged with the adaptation of tactics and techniques that had been developed in Afghanistan the previous year. Accurate firepower delivered by air strikes ensured the continued momentum of the ground offensive and was critical to the success of individual encounters, battles and the overall campaign. The 2003 Iraq War demonstrated the symbiotic relationship between air power and the ground offensive—a relationship that had so far been an unproven theoretical proposition.

Air power's speed of response, combined with the enhanced precision, proportionality and discrimination that has become an inherent part of air strikes, makes air power an indispensable element of a joint campaign.

In its evolved incarnation, air power was able to make creating the desired effect at the right time far easier than before; compensated on the ground for the numerical imbalance that was in favour of the adversary; and made it possible for the ground forces, functioning at the far-end of over-stretched and vulnerable lines of communication, to continue their advance without sacrificing any offensive momentum. In 2003, Operation *Iraqi Freedom* established the air campaign as an essential and critical part within the ambit of the Joint Campaign. Further, time-sensitive targeting moved from being merely wishful thinking to reality by the fusion of command and control (C2) arrangements that had so far been a stumbling block.

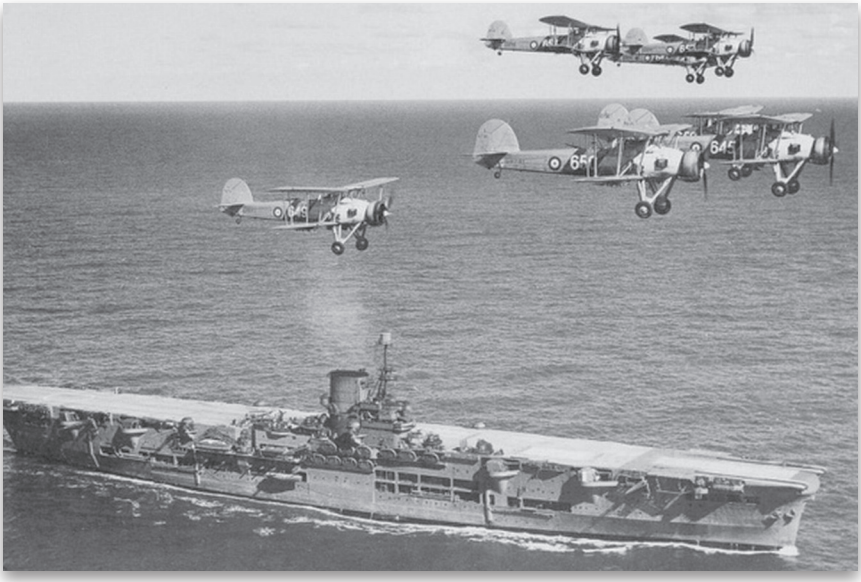
Within the span of just over a decade between the 1991 Gulf War and the 2003 Iraq War, the effectiveness of coalition campaigns had improved dramatically. The primary reasons for this improvement were the improved C2 arrangements that made timely and decisive actions possible; and the significant improvements that had been achieved in the understanding amongst the allies regarding the validity of a target system to be neutralised in order to create the desired effect. However, even with the substantial sophistication of communication networks and intelligence, surveillance and reconnaissance (ISR), the dissemination of information to the right person or agency in a timely manner continues to pose challenges in warfighting.

Most conflicts of the past three decades have subscribed to the concept of effects-based warfare and strategies, either partially or fully. The concept has been repeatedly validated and proven to fully achieve the desired end-state—initially militarily and ultimately at the political level. Even so, three identified challenges have yet to be fully ameliorated. One, determining what constitutes a valid target system, which when neutralised would create the desired effect(s); two, understanding the indirect and cascading effects that would be created and would linger on for far longer than the direct effect; and three, the lack of a robust method or process to measure the impact of the effects that have been created.

As yet, there are no comprehensive solutions to these challenges, primarily because the effects that are created are meant to influence the cognitive domain of the adversary human being, individually and collectively. It follows that a detailed understanding of the culture, ethos and myriad other intangible factors influencing the adversary is fundamental to understanding the effect to be created and in turn affects the selection of the target system to be neutralised. At least for the time being, it would seem that the three challenges enumerated above cannot be put to rest completely—only partial solutions are available even today.

Air power, reliant and enabled by high-end technology has repeatedly demonstrated its ability to carry out kinetic strikes with precision, proportionality and discrimination; to carry out ISR with unparalleled speed and accuracy; and disseminate information very close to real-time, thereby creating enhanced battlefield and strategic situational awareness. In doing so, air power remains the optimum capability for employment in the pursuit of an effects-based strategy.

The decisiveness that air power brings to a campaign built on an effects-based strategy cannot be substituted by any other element of power projection. Air power's extremely rapid reaction, flexibility and its agility to adapt to emerging circumstances makes it a decisive and primary capability in effects-based warfare.



HMS Ark Royal in 1939, with Swordfish biplane bombers overhead, was involved in the crippling of the German battleship Bismarck in May 1941
(Pathfinder #333)

A U.S. Air Force Boeing B-29 Superfortress bomber from the 19th Bomb Group (Medium) attacking a target in Korea in February 1951
(Pathfinder #331)

An air-to-air front view of an F-4G Wild Weasel Phantom II aircraft. The aircraft is armed with four AGM-88 high-speed anti-radiation missile (HARM) missiles
(Pathfinder #339)

U.S. Air Force Combat Controller from the 21st Special Tactics Squadron calls for close air support from an A-10 Thunderbolt II.
(Pathfinder #355)

Combat controllers give a C-130 take off clearance and provide air traffic control during a mission in support of Operation Enduring Freedom.`
(Pathfinder #332)

RAF Mk4 Chinook inserts troops onto a mountain-top
(Pathfinder #336)

General Atomics MQ-9 Reaper armed medium-altitude, long-endurance (MALE) unmanned aircraft
(Pathfinder #345)

Boeing 'Loyal Wingman' unmanned combat air vehicle (UCAV)
(Pathfinder #335)

Technology

The Accuracy of Air-Delivered Weapons (#342)

Key Points

- *Accuracy of air-delivered weapons has always depended on advances in technology.*
- *The accuracy of air-delivered weapons have improved since World War II but is still not 100%.*
- *Less mass bombing and greater targeting precision leads to better chances of survivability for attacking aircraft and fewer incidents of collateral damage.*

Ever since Italian Giulio Gavotti dropped grenades from his Albatros F-2 aircraft on 1 November 1911 during the Italo-Turkish War, there has been continuous and concerted efforts to improve the accuracy of air delivered weapons. In the early days of aviation, a reasonable degree of accuracy in dropping ordnance could be achieved as aircraft were relatively slow platforms but as aircraft became faster, the degree of accuracy waned. It was not until World War II that bombing moved from being considered an art to becoming a science.

The 'precision' of air delivered weapons is normally expressed as the 'circle error probable' (CEP). The CEP is normally described as the radius of a circle with the target at the centre. For example, if a group of aircraft dropping bombs were calculated to have a 100 metre CEP, it meant that there was a 50 percent chance of the bombs impacting within a circle radius of 100 metres with the target at the centre. However, even this degree of accuracy could not be achieved in World War II. It has taken decades of technological advances to obtain a level of accuracy which today can be expressed in metres rather than hundreds of metres or even kilometres from a target.

Prior to World War II, to place enough ordnance on a target to be effective, bombers were required to fly at low levels. This made the bombers vulnerable to anti-aircraft artillery and also made it easier for

enemy fighters to intercept and shoot them down. In 1921, the United States Navy drafted specifications for a daylight bombsight that would allow bombing from high altitude. Carl Norden developed a gyro-stabilised bombsight in 1923 and delivered the Mk. 3 to the Navy for trials. The first model was effective only against stationary targets. The next model was a gyro-optical device delivered in 1924. This version had a timing device which indicated to the bombardier when to drop the bombs. By 1931 the Navy had achieved impressive accuracy during trials. The United States Army Air Force (USAAF) also took note and placed their own orders. By this stage a Mk. 15 version had been produced and it was literally a bombsight with a plane attached to it. The bombardier assumed control of the aircraft during the bombing run and directed the pilot to make corrections to line-up the sight with the target.

Early in World War II the Royal Air Force (RAF) experienced heavy casualties in daylight bombing raids and changed their tactics to bombing at night. Unfortunately, the dark also worked to the advantage of the target. However, the equation would change when the US entered the war with the Norden bombsight, which was regarded as a game changer by improving the accuracy of air delivered bombs. It was claimed that the Norden bombsight was so accurate that it could drop a bomb into a barrel from 30 000 feet (9144 metres) which was a tall order given that the bombardier would not have been able to see the barrel from this height let alone hit it. However, such statements ensured that the Norden sight was held in such high regard as cutting edge technology that aircrew were instructed to ensure that the bombsight never to fell into enemy hands.

In 1943, the Norden M-series was delivered to the USAAF and it was estimated that this version was 6 to 8 times more precise than the Mk 14 bombsight, then in use by the RAF. An analysis showed that the RAF was capable of putting only 5 per cent of its air-delivered ordinance within a mile (1.6 kilometres) of their aiming point under combat conditions. In contrast, the 8th Air Force of the USAAF was believed to be able to put 24 per cent of their bombs to within 1000 yards (912

metres) of their intended targets. By 1944 this figure had risen to 40 per cent to within 500 yards (457 metres). The Norden bombsight enabled B-17 Flying Fortress aircraft to fly above ground-based air defences and still hit their target. The daylight bombing strategy became a viable option to take the war to Germany.

While the introduction of the Norden bombsight clearly provided a technological advantage to the USAAF, the substantial improvements in the success of the bombing raids should also be attributed to other significant factors such as the introduction of long range allied fighters which extended air superiority into the enemy territory.

In World War II, it would take 108 B-17s dropping 648 bombs to get two bombs onto an intended target which by the 1991 Gulf War could be achieved by a single aircraft using precision guided munitions, if the prevailing conditions were right. The World War II figure could be explained, in part, by only certain aircraft having the Norden bombsight, which became the lead aircraft on a bombing run with the remaining aircraft following the lead aircraft. If the leader was off the target then the aircraft that followed would also be off the target. The Norden was touted as the most accurate bomb site of the era but in 1943 it only achieved a CEP of 1200 feet (370 metres). By way of comparison, Word War II 'precision' dive bombers could put 50% of their bomb load within a 1000 foot (304 metres) radius of their target. Similarly, Germany also achieved some success with the Fritz x radio guided missiles as early as 1943, sinking the Italian battleship Roma (after Italy had changed sides) but no other targeting apparatus could match the Norden.

After World War II, the Norden bombsight underwent improvements and was last used in the Vietnam War. Vietnam heralded a significant change in targeting which was highlighted by the United States efforts to destroy the Thanh Hoa Bridge which was a vital link providing materiel support to the Viet Cong in South Vietnam. From 1965 until 1972 hundreds of mass bombing attacks on the bridge failed to neutralise it. However, in May 1972 the United States Air Force deployed 14 Phantom (F-4) aircraft with 26 air-delivered laser guided bombs that finally destroyed the bridge. This was made possible

through the development of a laser designator pod fitted to the aircraft termed 'Pave Knife' which enabled the delivery of precision guided munitions.

In turn, this set the scene for the future delivery of air-delivered weapons. Greater precision has resulted in less mass being employed to neutralise a target. Greater precision meant less collateral damage through avoiding the unnecessary destruction of enemy infrastructure and the loss of innocent civilian lives while ensuring the greater survivability of attacking aircraft and crew.

Future

Control of the Air: A Futuristic View (#340)

Key Points

- *Control of the air has, over the last few decades, been taken for granted by Western forces.*
- *An adversary in any future military campaign is likely to be a near-peer competitor whose skies would be heavily guarded, making air dominance a vexed issue.*
- *The future contest for control of the air will depend on platforms functioning as a complex system of systems, as opposed to the current practice of fielding a few but highly capable and sophisticated platforms.*

Ever since the US-led Western coalition launched Operation *Enduring Freedom* in Afghanistan, as a response to the attack and destruction of the twin towers of the World Trade Centre on 11 September 2011, these forces have fought wars against adversaries who have been overwhelmed by the sheer military power of the West. Of particular note is the fact that the Western coalitions have been able to dominate the skies with near-impunity, without even having to initiate a campaign to obtain and maintain control of the air. The adversaries of the past few decades have been irregular forces without even minimum air defence capabilities. Therefore, control of the air automatically came the way of the regular military forces who in turn took such control for granted.

The result of this one-sided air power equation has been that the air forces of the Western nations have focused on developing solutions to the challenges that they face in the immediate future, rather than focusing on evolving concepts and planning acquisitions for future conflicts. However, such a status quo was too good to last and the scenario has changed in the past few years. In the evolving geo-strategic environment, it has become apparent that any future military campaign would have a near-peer competitor in the adversary corner. This poses a challenge to air power

and air forces—it has become difficult to determine the evolutionary track that must be adopted to ensure that adequate control of the air can be guaranteed in the 2030s and beyond. The skies are gradually becoming contested and heavily guarded, making the development of the wherewithal and concepts for its dominance a vexed issue.

Most modern air forces have initiated at least preliminary experiments into technologies and are investigating force structures that would cater for the uncertainty that seems to be looming ahead from an air campaign perspective. The quest is on now for the next technological innovation that will create a step-change function in the application of air power.

The current confrontations are still being dominated by irregular adversaries reliant on the concept of asymmetry to equalise the balance of power, and therefore, the conventional military forces are not currently oriented to fighting and winning against potential peer-level adversaries. Modern air forces must expect advanced fighter aircraft, sensors and weapons to proliferate in any future conflict zone. These systems would make the campaign to achieve control of the air complex and hard fought.

For the past few decades control of the air has been built on lethality of air power application and the survivability of the systems that in turn are fundamentally dependent on the two characteristics of speed and manoeuvrability. With the technological developments that have brought about conceptual innovation, domination of the airspace will need to take into account the availability and exploitation of information. Assured access to information and its exploitation for one's own use, while being able to deny it to the adversary, would be critical in the future for achieving control of the air.

Information exploitation as a prerequisite to obtaining and maintaining control of the air would require the development of systems that have the appropriate sensors—on the ground and in the air and space. Further, these sensors must be networked to create a holistic picture that is accessible to all operators in as near real-time as possible. It will also be necessary to ensure the robustness of the network and its

redundancy, while also ensuring that bandwidth requirements are met. The move towards information exploitation does not mean that speed and manoeuvrability are not necessary attributes; they continue to be crucial to achieving control of the air. By sensing, processing, distilling and distributing information at a pace faster than the adversary, one's own air power assets will operate inside the decision-cycle of the adversary and therefore, will be in the best position to overwhelm the opposition.

Both conceptual and technological developments point to the possibility that a number of emerging technologies, which have yet to mature, will become critical to achieving control of the air over the next few decades. Traditionally the gestation period required to operationalise a platform with cutting edge capability from concept to reality has been long. One development that is being pursued is the concept of rapid prototyping involving the simultaneous development of the main platform and the necessary sub-systems, which would then be aggregated. This time-saving development is meant to avoid the long waiting time necessary today to acquire and field major systems such as fighter aircraft.

There is also tacit acceptance at the experimental and developmental stages that current systems that ensure adequate control of the air are far too expensive to risk being lost to enemy action. Both scientists and operators are analysing concepts that would ensure a large number of nodes so that the destruction of some of them through enemy action would not cripple the entire system. This concept is being called 'distributed space' as a working title. Similarly the concept of defending a vital asset by optimally employing stealth, electronic warfare and speed using platforms that are not too 'expensive', and therefore can be placed in harm's way, is also under consideration. Such innovative concepts will revolutionise the manner in which control of the air is achieved and maintained.

Emerging technologies include increased computation speeds, advanced communications, radio-frequency exploitation and a drive to increase automation within combat systems. The concept of a manned

aircraft controlling several uninhabited aerial vehicles representing a system of systems to gain control of the air could lead to air dominance. The combination of manned and unmanned platforms performing sub-sets of the same task has long been conceptualised and is now nearing the experimentation phase. The manned/unmanned pairing would have to develop trust between a human-controlled and automated platform that in turn will have the capacity to enhance the envelope of system performance.

The future contest for control of the air will be based on having many platforms—a judicious mix of manned and unmanned systems—functioning as a complex system of systems, as opposed to the current practice of fielding a few but highly capable and sophisticated platforms. Conceptual discussions have progressed to the extent of envisaging a few manned 'mother ships' being supported by, not hundreds, but thousands of uninhabited platforms that are specialised to perform sub-sets of complex and multi-faceted missions such as control of the air. An overarching factor on the clear need to dominate the airspace as a prerequisite for the success of all military operations is the need to achieve it at the best cost-benefit equation.

History

No Highway in the Sky (#344)

Key Points

- *Dropping bombs on a designated target has focused the attention of airmen since the advent of air power.*
- *During World War II, the RAF established the Pathfinder Force to improve the accuracy of aerial bombing.*
- *Australia had a pivotal role in the establishment and subsequent success of the Force with the appointment of a Point Cook trained commanding officer for the duration of its existence.*

What is a *Pathfinder*? At first glance it is a publication produced since June 2004 by the Air Power Development Centre, an issue of which you are reading at the moment. The title though has a more significant meaning. The title is meant to commemorate the Pathfinder Force that was formed in Bomber Command, Royal Air Force, during World War II. Without the contribution of the Pathfinder Force, Bomber Command would probably have been disbanded, which would have meant that the British contribution to the strategic air offensive against Germany would have been drastically reduced or may not have continued all.

Before it can create the necessary effect and become a useful air asset, a strike force must be able to locate the designated target. German air units operating during 1937 in the Spanish Civil War recognised that aerial navigational aids would be vital to reach the target, especially during bad weather and/or night. Accordingly, a special target finding Luftwaffe unit *Kampfgruppe* 100, was formed and made ready for action in November 1939. It employed an electronic navigational aid system based on radio beams, which intersected once the target was reached. Flares would then be dropped to illuminate the target for the incoming bombers. Perhaps the best-known application of this technique was the destructive raid on the British city of Coventry in November 1940.

The pre-war doctrine of RAF Bomber Command made no provision for night attacks. The basic belief was that a self-defending force of bombers could operate safely in daylight. For daylight bombing raids the only navigational aids deemed necessary appeared to be a map and a pair of binoculars. During this period, specialist navigational training was available for only two officers every year.

An aerial navigator's job is to know the position of the aircraft at all times. Today, much reliance is placed upon the Global Positioning System governed by signals originating 20,000 kilometres above the earth. The method employed by Bomber Command, however, before the introduction of the first electronic navigational aid in 1942 was a combination of dead reckoning and celestial observation. Dead reckoning relies on basic information such as the last known location of the aircraft, time elapsed, average wind drift, ground speed and direction. Celestial navigation involves reasonably complicated mathematical computations based on sextant star observations.

There were many opportunities for error, and navigators who until 1942 were also responsible for aiming the bombs, understandably made them. Examples highlight the point: a raid on Berlin by 103 aircraft in August 1940 resulted in the destruction of a suburban garden summer-house by the only bombs which fell within the city limits. In October 1941, crews were briefed to bomb Stuttgart. The bombs fell in the countryside well outside the city. Later that year, 152 aircraft were sent to attack Nuremberg. The raid resulted in the extended bombing of a small village sixty-five miles from Nuremberg with another small town 152 kilometres from Nuremberg being bombed for some hours.

Two specific reviews of bombing results showed the extent of such inaccuracy. The Butt Report of August 1941 based on the examination of 650 photographs covering 100 bomber raids indicated that generally only one in five aircraft reached within five miles of a designated target. A further report carried out by the Operational Research Section of Bomber Command in October 1941 produced even more dismal findings: only fifteen out of a hundred aircraft, it argued, managed to drop their bombs within five miles of the target point.

It is likely that between one half and three quarters of the bombs dropped at night were not even hitting the cities which they were supposed to be aimed at. Bomber Command clearly was in crisis: the formation of the Pathfinder force was a vital element, together with the introduction of the four-engined bomber, which made Bomber Command operationally functional.

In late 1941 there was a suggestion in the Air Ministry that a Bomber Command target finding force be established. Some groups were experimenting with 'raid leaders'. However, Sir Arthur Harris, appointed Commander-in-Chief of Bomber Command in February 1942, rejected the proposal to form a special force dedicated to finding the target. The Pathfinder Force was not established until August 1942.

It was thus almost a year from the Butt Report to August 1942 before the Pathfinder Force was established. In that ten months Bomber Command aircrew and aircraft had been lost on largely unproductive operations. Continual arguments between senior people were a source of delay. For example, it took several weeks before the British Treasury, considering the cost, would agree with a Harris request that aircrew of the new all-volunteer force, who were expected to fly 45 operational missions instead of the normal thirty in a 'tour', be promoted one rank. Air Staff officers were in favour of the proposed Pathfinder Force; operational commanders generally were not. Harris had a personal dislike for a main air staff proponent and had to be directly ordered by The Chief of the Air Staff to drop his opposition.

Initially the Pathfinder Force consisted of only five squadrons. By January 1943 it had doubled in size and formed 8 Group (Pathfinder Force) finishing the war with twenty squadrons. It was equipped with the most effective electronic navigation aids particularly the H2S airborne radar, specially designed flares and the highly versatile Mosquito aircraft. Technique followed the Luftwaffe model of finding and then illuminating the target. The destruction of many German cities followed.

The Pathfinder Force had only one commander, Donald Bennett, a Point Cook trained Australian pilot and navigation expert, a previous

RAF bomber squadron commander and, among other things, the holder of a number of long-distance flying records. In the course of a year he was promoted from Wing Commander to Air Vice-Marshal and at 33 became the youngest to hold that rank in the history of the Royal Air Force.

The Pathfinder Force flew a total of 50 490 sorties against some 3440 targets for the cost of 3727 aircrew killed on operations. It was disbanded in December 1945. It is often presented as an elite force but in fact its members were drawn from the main force operating squadrons. It was not always successful in what it attempted to do. Which organisation is? But if it had been formed earlier it may have saved many more Bomber Command aircrew lives and even perhaps have helped shorten the war.

In recognition of their special status all aircrew members of the force were entitled to wear the Pathfinder eagle badge on the left pocket but not on operational sorties given the possible repercussions if a crew member was captured by the enemy.

Air Power and Maritime Operations Part I: A Historical Perspective (#346)

Key Points

- *A maritime task force within range of an adversary's air power requires to be provided with air cover and friendly control of the air.*
- *A 'blue water' fleet may not be assured protection from enemy air action by shore-based aircraft because they could lack the range to do so effectively.*
- *Air power is a critical element in the projection of power through maritime operations.*

Air power today is a critical element in the successful conduct of maritime operations. In fact, truly 'blue water' capability cannot be claimed without air power—either deck-launched or shore-based. Historically, the employment of air power in the maritime domain is as old as its application on land. The first time a 'bomb' was dropped from an aircraft was during the Italo-Turkish War in 1911 and in the same year an aircraft was deployed from *USS Pennsylvania*, a cruiser of the US Navy. Around the same time, the Royal Navy also launched aircraft from a few of its existing ships.

Even prior to World War I there was an appreciation that aircraft could provide commanders at sea with information regarding the enemy beyond the horizon of the surface fleet. However, these aircraft were limited in their range and were only of marginal utility. A ship-borne aircraft carried out the first successful torpedo attack against a German ship in 1915, while it was in harbour. During World War I, the focus was on maritime reconnaissance and anti-submarine warfare conducted by shore-based aircraft, which demanded that answers be found to the challenges of long-range navigation at sea, air-to-ground/ship communications and ensuring the accuracy of the weapons dropped.

Rapid development in aviation capabilities—in its doctrine, concepts, technology and operational application—exemplified the inter-war years. In the maritime domain, the possible impact of air power and the threat they could pose to maritime trade, the central artery for national prosperity, was well-recognised. The fundamental need to protect the sea lines of communications, especially against enemy submarines, established the anti-submarine role of air power in maritime operations. The other role to emerge, conceptually, was the need to be able to project air power into the adversary heartland from both land and sea-based assets. Flowing from this was the requirement to achieve control of the air over the operating area of the sea—the answer was found in the development of aircraft carriers. Carrier-based aircraft could launch strike missions, dominate the operating area and wage war against the adversary's combat assets, both ashore and afloat. Further, they also have the added advantage of not having to obtain host country agreement to contribute to land-based operations. A classic example of carrier-borne aircraft providing strike capabilities in support of a land campaign can be seen in the early stages of Operation *Enduring Freedom* in Afghanistan.

Even before the start of World War II, air power had become an essential element of maritime forces. Naval aviation developed along two distinct lines, which are still prevalent even today. The first was shipborne aircraft that function as an integral part of a naval task group, which carry out the roles of air defence of the fleet, strikes against maritime targets, both surface and sub-surface, and reconnaissance. The second stream was shore-based maritime aircraft with long range and endurance employed for large area surveillance and reconnaissance and carrying out strikes against surface ships and submarines. By the early stages of World War II, the navy had moved considerably on the path to becoming a 'sea-air' service. The major navies of the world had switched to the aircraft carrier as their capital ships. This move was the harbinger of the demise of the battleship that had so far been considered critical to winning maritime battles.

It was during World War II that naval aviation came into its own. Its critical influence and decisive impact on the outcome of campaigns were felt in all theatres of the War. Surface ships and submarines of both the allies and the axis powers came under attack from both shore-based maritime aircraft as well as carrier-borne fighters. Perhaps more important but a less mentioned role of maritime aviation was the critical part it played in protecting merchant shipping and seaborne trade, which was vital for sustaining the war effort. History demonstrates that maritime aviation made a crucial contribution to ensuring that the sea lines of communications were kept open.

The Japanese Navy's attack on Pearl Harbor on 7 December 1941 could be considered the definitive coming of age of naval aviation as a distinctive element in military power projection capabilities. The Japanese carrier-borne aircraft flew a distance of nearly 300 miles and carried out a massed torpedo attack that sank or severely damaged seven of the eight US Navy battleships berthed in the harbour in an exuberant demonstration of the prowess of carrier-borne aviation. A few months later, in mid-1942, the Battles of the Coral Sea and Midway Islands were the first sea battles where aircraft carriers employed their embarked aircraft to achieve the desired effects without the surface forces having to come within gun range distance. The aircraft had replaced the gun as the primary offensive weapon in sea battles. Although the term 'revolution in military affairs' (RMA) was coined at a much later date, the offensive use of aircraft to win battles when the competing surface ships were not even in sight of each other could be considered the RMA of the time. From 1942 onwards, any maritime surface force operating without embarked air assets would be considered deficient in its offensive capabilities.

The primacy of air power at sea was recognised by the end of World War II. Therefore, all major navies planned to develop/acquire their own naval air arm and nearly a dozen navies came to possess and marginally operate aircraft carriers in the few decades following World War II. In the second half of the 20th century, aircraft carriers and their embarked air power assets were used as quick reaction capabilities to contain or

respond to emerging political and/or military crises in global hotspots. The list is almost endless—Korea (1950), Lebanon (1958), Taiwan (1958 and 1996), Kuwait (1961), Cuba (1962), Vietnam (1964), Libya (1981), Falklands (1982) and the multiple crises in the Middle-East over the past four decades.

The recognition of the efficacy of carrier-borne air power to respond to various contingencies and the fact that aircraft carriers were considered cost-effective as well as instantly mission-ready made the US develop nuclear-powered aircraft carriers. In turn, these carriers greatly expanded the operational envelope of seaborne air power and its 'staying power'. Similarly, many technological innovations such as catapult launch and arrested landing, angled deck and ski jump greatly improved the efficiency of maritime air operations. The introduction of other sophisticated technologies—electronic warfare systems, improved intelligence, surveillance and reconnaissance capabilities, enhanced command and control systems and sonar and sonobuoys for anti-submarine operations—have enhanced the effectiveness of maritime air power, whether shore-based or seaborne. The aircraft carriers themselves have become floating air bases capable of launching the same quantum of offensive air power as that of a small air force.

Control of the air over the area of operations at sea has become a prerequisite for victory in maritime operations. The aircraft carrier, with its speed, mobility and flexibility to operate large numbers of aircraft for sustained periods, provides the necessary control of the air for other naval forces to conduct their operations without undue interference from adversary air and even maritime forces. This is the fundamental advantage that air power provides to maritime operations.

The Pursuit of a Strategic Strike Capability (#347)

Key Points

- *The F-111C provided Australia with a truly strategic air power strike capability for the first time.*
- *The path to acquiring the F-111C reflected the difficulties in reconciling the Air Force's requirements with available options for a strategic platform.*
- *In selecting the F-111C, the Air Force accepted a significant technical risk involved in a highly complex and unproven platform.*

The immediate post-World War II period marked a time during which the RAAF sought to maintain its strategic bomber capability. The broader context of the Cold War, the transition of air power to the jet age and the Air Force's modernisation plans would eventuate in the order for twenty four F-111 strike aircraft. The induction of the F-111 heralded the development of a truly strategic strike capability in the RAAF. What is little appreciated, however, is the convoluted path that was followed in the preceding decade, which finally led to this watershed moment in the development of Australian air power.

World War II was a turning point in the evolution of Australian air power capabilities. In 1939, the Air Force was a tactical air arm primarily focused on support to land and maritime operations. Notably, the RAAF had minimal doctrine and capability devoted to the concept of strategic bombing despite developments amongst the leading air forces of the time. However, during the course of World War II the RAAF established heavy bomber squadrons that employed leading edge platforms such as the Consolidated B-24 Liberator. By the end of the war, the RAAF had developed extensive experience of strategic bombing in both Western Europe and the Pacific theatre.

In the immediate aftermath of the war, the RAAF sought to become a modern air force suited to the newly emerging tensions of the Cold War.

The ability to project strategic effects was a key feature of this vision, which, in part, reflected its standing as the fourth largest air arm at the end of World War II. Initial planning conceived an air force of 35,000 personnel and 34 squadrons including some 134 Liberator heavy bombers. However, the realities of a peacetime economy forced the Air Force to curtail its ambitions and accept a more modest force structure. In the end, the RAAF was limited to a force of 8,000 personnel and sixteen operational squadrons, which included just three heavy bomber squadrons.

Despite the limitations, the Air Force proceeded with its modernisation, which underpinned its transformation to jet-age air power. In terms of strike capability, this was reflected in the acquisition of the English Electric Canberra medium bomber, which entered service in 1953 with 82 Wing. While providing a distinct improvement in capability over the piston-engined Lincoln bombers it replaced, the Canberra nonetheless was somewhat limited in its range and payload with little advancement in the accuracy of its bomb delivery. Despite these limitations, the Canberra provided sterling service in maintaining a regional capability advantage, although its strategic impact was limited because of Australia's unique geography.

To address the lack of a true strategic strike capability, the Air Force commenced looking at options to replace the Canberra. Notably, this search for a replacement platform also coincided with the debate regarding whether or not Australia should acquire a nuclear deterrent capability.

By early 1954, only one year after the Canberra's introduction to service, the Air Staff had consolidated its ideas for modernising the bomber force into a formal Air Staff Requirement (ASR) – OR/AIR 36 – with an anticipated in-service date of 1959 for a fleet of 39 aircraft with a sixteen year service life. The requirement specified that the replacement should: "...fulfil the strategic bombing role, by attacking targets up to its maximum radius of action with a formidable bomb load by day or night." Typically, the aircraft was required to have a 2000 nautical miles range and all-weather operating capability. The ASR resulted in a team led by Air Vice-Marshal Murdoch investigating aircraft options available in the UK and US. The outcome was the recommendation that the RAAF should

acquire either the Avro Vulcan or the Hadley Page Victor bomber from the UK, both of which were primarily nuclear-capable heavy bombers. This recommendation accorded with Air Chief Marshal Sir Frederick Scherger's thinking on the imperative of the RAAF having a regional strategic strike force.

While consideration for a new bomber force progressed, the idea of nuclear weapons for strategic effect became hotly debated. Scherger was a key proponent of the acquisition of nuclear weapons to be air-delivered. He envisaged the acquisition of tactical weapons for initial use on the Canberra and Sabre, and subsequently for strategic employment on the new bomber. Scherger believed that such an acquisition would allow the RAAF to remain at the cutting edge of air power through contributing nuclear-armed heavy bombers as part of an allied deterrent force in South East Asia. This was perceived to be a valuable contribution for a small Australian defence force in offsetting Communist expansion in the region. Despite the apparent strategic rationale for acquiring the weapons it was contrary to national policy and there were also significant hurdles: primarily, technological considerations, the high cost of developing support infrastructure, and command and control arrangements. These difficulties militated against Australia proceeding down the nuclear path.

With the loss of support for a nuclear option, Scherger conceded that the argument for a V-bomber class of aircraft as a replacement for the Canberra was also moot. Nonetheless, there remained an ongoing need to eventually replace the Canberra noting its age and limitations. By the late 1950s, the UK's development of the TSR-2 appeared to offer an attractive option: supersonic, long-ranged, and employing advanced navigation/attack systems. Scherger considered the aircraft as a perfect match for the RAAF's requirements. Doubts, however, lingered regarding the level of political resolve in the UK to introduce the aircraft into service, since there was mounting opposition to the high cost and technical issues involved in developing and fielding such a complex platform. This uncertainty made the RAAF search for other alternatives. (For more details see *Pathfinder* No 72)

The new search for a Canberra replacement culminated in another team investigating aircraft from the UK, US and France in 1963. Led by Air Marshal Sir Valston Hancock, the team identified that the American TFX, which would become the F-111, best met the RAAF's requirements. However, the design had yet to fly and could not meet the Air Force's desire for a more immediate replacement. Accordingly, Hancock recommended the dated North American RA-5C Vigilante to meet the need for the strike/reconnaissance force.

This option, however, was met with a measure of alarm in that it was perceived to trade capability for expediency and the recommendation was not accepted. Noting the potential of the TFX, despite the risks inherent in an embryonic program of a very complex platform, the decision was made to make a direct approach to the US to pursue a possible acquisition. In part, the Australian decision reflected the strong US political support for the aircraft, which was to be acquired by both the US Air Force and Navy. Favourable terms and the assessment that aircraft was the ideal aircraft for the RAAF resulted in the Technical Agreement to acquire the F-111 being signed in 1964. After a decade of almost fruitless searching for a replacement for the venerable Canberra it finally appeared that the RAAF had its aircraft. Despite this favourable outcome, it would take another decade of troubled development and uncertainty before Australia's F-111C variant would finally be introduced into service and provide the RAAF with a truly strategic air power strike capability.

And the rest, as they say, is history.

Contributors

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