PATHFINDER

COLLECTION - VOLUME 9

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Foreword

This ninth volume of the *Pathfinder Collection* brings together another 36 of the Air Power Developments Centre's bi-weekly *Pathfinder* bulletins. The bulletins have now been issued continuously for 15 years as hard copies and online. Although the authors who contribute come from a diverse array of backgrounds, I would like to thank Professor Kainikara for being our most prolific writer. He has 21 Pathfinders in this collection alone and has written 99 in total, a significant achievement.

The covers for the *Pathfinder Collections* are usually chosen from the contributions of artists who enter their art works in the RAAF Heritage Awards. The cover of this collection was painted by Ben Patynowski, who depicted the RAAF Heron A45-274 UAV engaged in Operation *Tevera Sin* over Afghanistan in 2011. Ben's painting was the 2012 winner of the RAAF Heritage Awards and is currently held in the RAAF Museum, Point Cook and now as a book cover it will have a wider audience. Keen observers may notice the reversed roundel on the right hand side of the Heron. This a true depiction of the aircraft as it was delivered. However, a forward facing kangaroo was added prior to commencing operations over Afghanistan. The artist offered to correct the painting to make it more historically accurate but the selection panel thought he should leave the roundel as originally painted because it highlights a unique and interesting fact about the aircraft.

I hope that this collection encourages other writers and artist to make contributions to the APDC *Pathfinder* bulletins and the RAAF Heritage Awards, as they help to enhance our understanding and professional mastery of air power topics.

Please enjoy this volume.

GPCAPT Andrew Gilbert
Director APDC
July 2019

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. Comment on this publication or inquiry on any other air power related topic is welcome and should be forwarded to:

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Air Power Theory & Strategy

Classical Theories and Air Warfare (#290)

Key Points

- *Air power's ability to attack targets of choice changed the conduct of war irreversibly*
- *The early air power theorists were quick to establish the theories and concepts for the application of air power as a military force*
- *The foundational requirements for the success of an air campaign has remained the same through more than a century of its application as an element of national power.*

The exploitation of the third dimension for military purposes, brought about by technology, rapidly changed the manner in which the industrialised nations practised the art and science of warfare. Early air power theorists sought to fill the conceptual gap the new technology created drawing on the limited experience gained in World War I. The classical theories of air warfare started to be considered on the merit of their logical persuasion only after a century of air power application as an instrument of military power. The foundations for the application of air power were formulated on visions rather than practical experience. In sharp contrast, the theorists of the armies and navies have distilled several centuries of historical experience to bring forward eclectic views on the characteristics and conduct of surface warfare.

The ability of a military force to directly attack an enemy nation's civil population, it's war economy and even the political structure, as well as its military forces deployed on land and at sea, has been an advancement without precedent and parallel. This ability revolutionised the conduct of warfare.

The advent of air power provided war-planners with the wherewithal to strike at the heart and centre of the adversary—the centres of gravity that when destroyed or neutralised diminishes the adversary's ability to make war to an extent where victory is easily achieved. The other aspect of air power is its demonstrated ability to create attrition on a scale that was never before possible, as demonstrated during the attrition-based World War II. The bombing of

Dresden is a classic example of such a capability. There is good reason for the on-going and acrimonious debate regarding the ethics, morality and legality of the employment of air power in a war of attrition.

The early theorists—notably Douhet, Mitchell and Trenchard—like all prophets, were guilty of being ahead of their time. Even though they tended to be dogmatic in their arguments, they established the basic assumptions that have subsequently created an appreciation of the critical role of air power in the conduct of all, and any, kind of wars. However, criticism of the classical theorists have focused almost exclusively on what they are perceived to have got wrong, rather than what they got right. The ascendancy of air power as a crucial element of national power has also been based on the intellectual outpourings of the early theorists. The comprehensive philosophy that now underpins the employment of air power to ensure national security, considered in its broadest description has also stemmed from the theories and concepts that were advocated in the 1920s and 30s.

The early theorists recognised four factors as being the driving force for the development of air power in its infancy. These factors continue to be the foundation for the rapid improvements in air power capabilities that have become almost routine. First, the need to obtain 'mastery of the air' and to keep it for the duration of the campaign/war, which automatically means having to fight for it continually. This requirement has to be tailored within a given context to the level needed and in terms of time and space, since obtaining uncontested air supremacy will not be possible even if the opposing air power capabilities are rudimentary. Second, is to provide own forces the ability to conduct operations without undue interference from the enemy, which is intimately connected to the requirement to be able to maintain the level of combat capabilities necessary to achieve control of the air. A standing force, capable of thwarting the adversaries' efforts at disruption of one's own campaign in the air, on the ground, and at sea is essential to ensure overall success.

The third is the ability to destroy the adversaries' centres of gravity, whether they are production centres, communications hubs, or leadership targets. This ability is built around the capacity to 'strike', leveraging air power's inherent characteristics of speed, reach and perspective that combine to produce a rapid response to emerging threats. Further, the ability of air power to create precise, discriminate

and proportionate effects gives it the ability to be a strategic weapon of great flexibility. Fourth, is the ability to carry out one's own disruptive activities, so that the adversaries are unable to support their efforts at prosecuting their own campaign. This would mean cutting off the adversaries' supply chain and lines of communications at nodal points.

The current combat requirements of air power have emanated from these basics. Air power's capacity to achieve the above fundamental objectives have been greatly enhanced over the years through technological sophistication. Technology has added other force multiplying capabilities to air power, such as: Airborne Early Warning and Control systems that enhance situational awareness at all levels of combat; air-to-air refuelling aircraft, which greatly increase the reach and loiter time of combat platforms; and uninhabited aerial vehicles that reduces the risk to human crew, especially in contested air environments.

Air power further contributes to warfighting in a manner that was not readily apparent when the early theorists formulated the concepts of air power application. This contribution is in the realm of air power transportation, or airlift. In the modern world, trade and commerce are the mainstays of a nation's prosperity. The need to rapidly transport much needed items from place to place is an enduring requirement to meet emerging demands in peace and in war. In times of calamities, natural or human-created, the need to transport items required to deliver humanitarian aid is critical. Air power provides the capability to meet the initial needs in such cases. Sea transportation will continue to be the long-term solution to 'moving things' across the world. However, in times of dire necessity, in war or peace, airlift provides the answer.

Although the classical theories and their strong advocacy by the early theorists were responsible for the creation of independent air forces, the demands being placed on a nation's air force today are very high. In fact, there are only a handful of air forces across the world who will be able to meet all the demands every time. Therefore, air forces have to nurture the inherent flexibility that they have in order to switch focus at very short notice. The early theorists did consider this possibility and very strongly advised against the tendency to penny-packet air power assets by dividing their command and control to small groups in an attempt to meet disparate requirements. Analysis of air campaigns has repeatedly proven that flexible application is the answer

to inadequacy in the quantum of air power assets and not penny-packeting.

A holistic analysis demonstrates that the theories and concepts put forward by the classical theorists, even though some of them were considered heretical at that time, have withstood the test of time. The basic requirements of an air force has remained the same: ability to control the air and strike the centres of gravity; rapid transportation of personnel and materiel through airlift; and the creation of adequate situational awareness by carrying out intelligence, surveillance and reconnaissance (ISR) and disseminating information gathered. The art and science of air warfare owe their robustness to the visionary concepts that early theorists developed and propagated. Without those foundations, air power may have continued to be a secondary capability, especially considering the animosity that was displayed against independent air forces in the early years. Like the technology that made air power the current 'weapon of first-choice', the theories and concepts of the classical air power thinkers cemented it's position at the vanguard of power projection capabilities.

The Concept Of Strategic Air Power (#291)

Key Points

- *The concept of strategic air power is built around the conduct of an independent air campaign that is directed against the war making capacity of the adversary.*
- *There are three principles regarding the application of military power that is inherent in air power—mass, economy of force, and objective.*
- *Irrespective of the circumstances, control of the air is a pre-requisite for the success of all other operations.*

At the end of World War II, General Carl A. Spatz, the first Chief of Staff of the independent United States Air Force stated, 'World War II might have ended differently had our enemies understood and made correct use of Strategic Air Power.' In 1942, Germany was at the height of its power and had made Europe into an impregnable fortress, immune to attack by any time-tested method of warfare. The situation pointed to the need to develop a new concept of warfare in order to avoid what would otherwise have been a prolonged war of attrition at an enormous cost in blood and treasure. The new technique that was chosen to take the war to an ascendant adversary was the concept of strategic air power.

In World War II, the concept was built around the conduct of an independent air campaign that was directed against the war-making capacity of the adversary. The air campaign did not have any direct connection to other surface battles and campaigns that were being conducted simultaneously. From the basic process of attacking the adversary's potential to wage war, the concept has evolved to being a primary mission of air power in war. While the ability to conduct a strategic air campaign is a critical capability in conventional wars, the concept has been adapted to suit irregular wars that have become common in recent decades.

There are three principles regarding the application of military power that is inherent in air power, which in turn makes a strategic air campaign easily tailorable to contextual requirement. First is the

principle of mass. Air power has the ability to bring to bear forces from widely distributed bases onto a single target simultaneously. The capability to concentrate force rapidly is unique to air power. Second is the principle of economy of force. Air power can neutralise selected target systems with minimal waste of effort, leveraging off the characteristics of its weapons systems—precision, proportionality and discrimination. Even within a target system, air power can select the vital point for destruction, achieving the effect of neutralising the system. The third is the principle of objectives. The ability of air power to penetrate and reach far into the interior of enemy territory facilitates the destruction of selected objectives that are vital to the war making capacity of the adversary. These objectives are the centres of gravity of the adversary and the ability to neutralise them from a great distance is unique to air power.

A strategic air campaign is an element of air power that manifests as an instrument of national power that is capable of paralysing the adversary's military power in a responsive manner. More important is air power's ability to create effects that will have long-term implications for the war-making ability of the adversary through targeting industrial and manufacturing capabilities. In addition, technology has facilitated air power to be able to deliver tremendous striking force with unprecedented swiftness in parallel—deliberately destroying communications facilities, supply chain and transportation hubs and fuel storage and plants.

The success of a strategic air campaign is dependent on the air force being able to obtain and maintain adequate control of the air. Control of the air is a prerequisite to conduct a sustained strategic campaign. Since the strategic campaign would inevitably have to be carried out over enemy territory, obtaining control of the air will itself necessitate an independent air campaign. Further, there will also be the need to continually 'fight' to retain the necessary level of control of the air as long as the strategic air campaign is in progress. The resource requirements to conduct two independent air campaigns simultaneously—one for control of the air and the other the strategic air campaign—may not be available to some air forces, in which case the objectives would have to be suitably altered downwards.

The concept of strategic air power is not new, it stemmed from World War II and was refined through repeated analysis and adapting

to the evolving character of war. Strategic employment of air power was, and even today is, not as readily understood as the traditional tactical application of air power. After more than 60 years of developing the concept of strategic air power, experience provides few pointers that will directly influence its effectiveness as a strategic instrument. One is the lead-time required to acquire and bring together the hardware, operational concepts and tactical training to create a system of systems that can effectively carryout a strategic campaign. There is also a requirement for the force to possess the technological sophistication to accept the capability and readily operationalise it.

Two, the efficient application of air power requires a unique understanding of the third dimension that only comes with adequate professional mastery of the individual and collective force. Air power has a strategy and operational concept of its own, peculiar to functioning in the third dimension. It follows that the principle guiding the command and control of air assets would vary from those of surface forces. The post-World War II period saw the entrenchment of the air power tenet of 'centralised control and decentralise execution', where the centralised command is left unsaid as being understood. With the advent of 5th-generation air power systems, this tenet has started to evolve more towards 'distributed control and decentralised execution'. Only a professional airman will be able to assimilate the nuances in employing air power.

Three, military forces have not only got to be 'joint' in operations but starting at the planning stage itself. Within this joint calculations, the air force must be given its independent campaign of strategic importance. An integrated approach to the application of force does not mean that individual Services and their operations are subsumed into one holistic plan. It only means that the objectives of independent campaigns must be aligned to support the ultimate goal of the war, first military and then political victory. The need to conduct a strategic air campaign gets emphasised in this calculation.

Four, whatever the circumstances, control of the air is the primary pre-requisite for the success of all other operations. In contemporary campaigns, most of the irregular adversaries do not have any credible air power capabilities. Therefore, the need to carry out a dedicated campaign to obtain and maintain control of the air has gradually been

forgotten. It has to be reiterated that sustained operations of any kind cannot be carried out without first having control of the air.

The concept of a strategic air campaign does not invalidate the requirement for a surface campaign. Wars will only be won by an optimised, jointly planned, and integrated application of land, maritime and air power. Air power however provides the wherewithal to avoid a lengthy war of attrition and may even be able to decide the outcome of a campaign even before surface forces have to engage the enemy in major battles. This is the unique ability of air power.

Air Power: Altering the Character and Conduct of War (#294)

Key Points

- *War is an instrument of political policy and therefore its nature does not change.*
- *The character and conduct of war and armed conflict change with context and are evolutionary at all times.*
- *From its inception, air power has been an instrument of change both in altering the character and the conduct of war.*

In any discussion of war, three factors are considered fundamental to understanding its nuances—the nature of war, its characteristics and its conduct. These factors, while being independent, are also indelibly intertwined and influence each other both directly and indirectly. To gain an understanding of the nature of war, it is necessary to explain war itself. In a very broad manner, war can be defined as a violent clash of interests between or among organised groups, normally characterised by the use of military forces. Traditionally, these groups have been established nation-states. However, throughout history, there have also been non-state groups who have waged war. These non-state groups, which have proliferated in the past six or seven decades, pursue their own political interests, mostly contrary to the state within which they operate. They wage war when they gather the ability to generate organised violence on a scale that is sufficient to create significant political consequences.

In today's context, war and armed conflict are treated as synonymous terms, although there is a subtle difference between the two. Armed conflict implies the pursuit of objectives through organised violence by any group able to do so, whereas war can be described as an extreme form of armed conflict that usually takes place between states. Even though the recognised international community consists of sovereign states, armed conflicts are more often fought by a non-state group

attempting to impose its will on another similar group or even the government of a nation-state. The result is a noticeable blurring of the lines that demarcate war, armed conflict, conflict, terrorism, crime and peace. The transition from war to peace is not a definable moment any more.

The famous strategist Carl von Clausewitz has described war as, 'the continuation of policy by other means'. It follows that if war is an essential instrument of policy, then the military objectives of the war should support the political objectives, which also shape the scope and intensity of the military operations.

The ***nature*** of war describes its unchanging essence—it describes the fundamental differences between war and other human undertakings. By its nature, war is violent, interactive and fundamentally political. If even one of these elements is missing from a human undertaking, that action is not war, but some other endeavour. The ***character*** of war describes the way in which a particular war manifests directly in the physical domain and indirectly in the cognitive domain. As war is directly aligned with the political aims of a state or group, its character will be shaped by those politics and societies—by what Clausewitz called the 'spirit of the age'. The ***conduct*** of war is undoubtedly influenced by technology, law, ethics, culture, morality, societal norms, type of government, military organisation and myriad other factors that evolve and change in a contextual manner.

In recent times, a number of analyses and articles, primarily those examining the 'revolution in military affairs', have mentioned that technological advances are driving changes in the 'nature of war'. Nothing could be farther from the truth. The nature of war is unchangeable and remains the pursuit of political objectives. While the conduct of war, the methodology employed to 'fight' it, will continually evolve and alter, and the character of war will be contextually different in each individual case, the nature of war will remain constant.

Ever since it arrived on the scene as an element of military power in World War I, air power has been an agent for change, by introducing technology-enabled capabilities that have altered both the character as

well as the conduct of war. Its impact on warfare has been enormous, essentially brought about through technology. This impact and its indelible connection to technology could be the reason for the wrong perception that technology has been altering the nature of war.

At its inception during World War I, the observation and surveillance capabilities of air power very rapidly negated the manoeuvre options of the adversary. In turn, the inability to carryout flanking manoeuvres contributed to the now infamous 'trench warfare' and its appalling casualty rate. The face of war had changed for ever. Similarly in World War II, air power was employed as the only means to attack the German forces and territories in the initial years of the war. The concept of land borders and their defence by the army of the nation was proven to be unsustainable very quickly. The character of war once again changed irrevocably.

The concept of control of the air as a prerequisite for the success of any other operation also became apparent during World War II. Ever since then, every military force in the world strives to obtain and maintain control of the air to ensure that surface operations can be undertaken without enemy interference. The preponderance of lethal power vested in the military forces of the developed nations and the rapid response to emergent situations that air power provided were two of the catalysts that changed the character of conventional wars. They entrenched the idea of asymmetry and irregular wars, conceived to overcome the inherent disadvantages that non-state groups faced. This form of warfare has now become the norm.

Air power and Special Forces were the first to adapt to this new normal. Air power turned itself into an asymmetric asset for the military forces, becoming a critical element in prosecuting an irregular war. In the process, it once again dictated changes to the character of war as well as its modus operandi.

The core roles of air power—control of the air, strike, air mobility, and intelligence, surveillance and reconnaissance (ISR)—continue to be optimised through technology-enabled advances. The changes to the operational and tactical application of air power brought about by these

improvements, in turn, influence and alter the character and conduct of operations of military forces.

The nature of war has not changed—it remains eternally connected to the political objectives of the nation as an instrument of national policy. However, the character and conduct of wars, and all other forms of conflict, are in a continual state of flux, changing and adapting with time and context. In this evolution, air power has played a significant role and continues to do so.

Effects of Air Power on Joint Campaigns (#298)

Key Points

- *The employment of air power in a military campaign is based on the two fundamental requisites to victory in the battlefield—manoeuvre/movement and firepower.*
- *Air superiority permits unrestricted manoeuvre opportunities to the joint force, a state of freedom that is necessary irrespective of whether the joint campaign is land-centric, amphibious, or maritime.*
- *In the air campaign plan, strikes will have to be tailored based on the role that air power is expected to play in the broader joint campaign.*

The joint, or integrated, employment of air, land and sea power in modern warfare blurs the demarcation of the effects created by the air force, army or navy to an extent wherein only joint effects are noticeable at the operational and strategic levels. However, it is possible to determine the positive effect created by each Service in its own role and the influence that is brought to bear on the overall campaign. The easiest way to analyse the contribution of individual Services would be to calculate or predict the result of the joint campaign being studied, if one of the three elements were missing.

It is an axiomatic fact that total victory can be achieved only by physically dominating the land, sea and air domains while achieving virtual supremacy in space and cyber domains. However, achieving such a state of superiority may not be possible in all circumstances, especially in the currently prevailing global security environment. Even so, the contribution of air power to all kinds of campaigns can be listed and described. Air power's contribution to achieving the desired end-state in a campaign is critical and of such importance that the core roles of air forces have been developed based on this requirement—control of the air, strike, intelligence, surveillance and reconnaissance (ISR), and air mobility.

The employment of air power in a military campaign is based on the two fundamental requisites to victory in the battlefield—manoeuvre/movement and firepower. In turn, the ability to manoeuvre and to deliver the necessary firepower, at the right place and right time, is dependent on air superiority. In this context, manoeuvre is being mentioned as a holistic requirement for surface, maritime and air forces engaged in prosecuting the joint campaign. Freedom from air attack becomes a non-negotiable requirement for joint forces to manoeuvre or move rapidly and efficiently. There is no 'defensive' aspect to gaining and maintaining air superiority. The term 'air superiority' is used to indicate that, of the several different levels of control of the air that can be obtained, the optimum would be air superiority, which would permit unrestricted manoeuvre opportunities to the joint force. This state of freedom is necessary irrespective of whether the joint campaign is land-centric, amphibious, or maritime.

While gaining and maintaining air superiority is an offensive effort, denying the use of airspace to the adversary also forms part of the broader air campaign, which fits in as a sub-set of the joint campaign. Here, the term air campaign needs a brief explanation. An air campaign is only the actions initiated by the air element, within a joint force and within the guide-lines of the joint campaign plan, to produce the unique effects that air power has to produce to ensure the progress of the joint campaign. It is not to be construed as an 'independent' campaign being mounted by the air force on its own—it is the equivalent of the land or the maritime campaign plans constructed by the land and maritime commanders, within the joint force.

It was in World War II that air power was used for the first time as a prelude to, and preparation for, surface operations. From the success of such application developed the fundamental theory of the employment of air power and air warfare. The use of air power to strike targets that could otherwise become obstacles in the advance of surface forces was refined to its pinnacle in the Gulf War against Iraq in 1991. However, the other side of the coin is that it is doubtful whether air power alone could conquer a strong adversary. An understanding of this aspect at the apex of the joint forces is important to the concerted employment of air power in conflict situations.

If air strikes are fundamental to the success of a maritime, amphibious or land campaign, then the most effective manner of

employment would be against the adversary's military forces that are opposing one's own forces. On the other hand, if air power is being employed to bring about a decisive result by itself, then the attacks should be aimed at less tangible strategic targets such as the political and administrative controls of the state, enemy economy and other centres of gravity that would undermine the will of the adversary to resist. In both cases adequate measures must be undertaken to ensure air superiority. In the air campaign plan, strikes will have to be tailored based on the role that air power is expected to play in the broader joint campaign. Air power can, and when optimally employed, does make a decisive contribution to the surface campaign. The effectiveness of the application of air power is directly proportional to the ability of the joint forces to exploit the air superiority that would have been obtained.

ISR provides air power the information necessary to identify the target that would, when neutralised, debilitate a selected centre of gravity. ISR is not a kinetic role of air power in combat, but provides the background that is critical to the effectiveness of the pointed end of the spear. The increasing importance of ISR in modern combat has evolved from two factors—the changing character of war that has become asymmetric and irregular, moving into combat within the civilian population; and the political requirement foisted on the military forces to avoid 'all' collateral damage, even though the Laws of Armed Conflict do permit unavoidable collateral damage in combat situations.

Rapid manoeuvre and highly mobile surface operations often stretch the capability of ground forces to logistically sustain them. Air mobility, through both fixed-wing and rotary assets, can support these operations through air supply so that the momentum of advance is not lost. Air supply and evacuation, when required, can assume an importance out of proportion with the actual total lift carried out. In an irregular warfare scenario, air mobility also facilitates the operations of Special Forces through insertion, sustainment and extraction carried out at short notice. The added advantage of such operations is that a numerically small force will be able to 'control' a geographically large area when sufficient air mobility is made available.

In the conduct of a joint campaign, air power is a critical element that could determine its success in the battlefield as well as in achieving the desired end-state. In the integrated application of a military force, no one element is superior, supporting or supported. The modern

battlefield dictates that each capability has its own unique contributions to make and if one is found wanting, the joint campaign is unlikely to succeed.

The Fundamentals of National Air Power (#299)

Key Points

- *At the strategic level of national security considerations, air power is a national power element.*
- *National air power is not composed only of the war-making components of aviation, but is the total aviation activity, civilian and military, commercial and private, potential as well as existing, within the nation.*
- *Five factors influence the development of adequate national air power: geography, demography, resources, industrial development and political conditions.*

In 1925, Brigadier General William Mitchell defined air power as the ability to do something in the air. Mitchell added, 'It consists of transporting all sorts of things by aircraft from one place to another, and as air covers the whole world there is no place that is immune from influence by aircraft.' From this very broad definition, has grown a large number of definitions with the Air Force defining air power as, 'The ability of a nation to assert its will by projecting military power in, through and from the air domain.' This is a nuanced and explicit definition, more suited to the explanation of a highly sophisticated, complex and technology-enabled capability as air power, resident in the military forces.

At the strategic level of national security considerations, air power itself becomes a national power element. Accordingly, the definition of air power broadens into, 'National air power is the total ability of a nation to achieve its objectives through the air domain and encompasses all elements of civil and military aviation.' The fundamentals of air power are derived from a clear understanding of national air power. Ever since the end of World War II, air power has been a force for change not only in the employment of military forces, but also in the political, economic and social structure of the world.

The characteristics of air power have demolished the historic politico-geographic system based on the existence of 'national boundaries'; some natural, some artificial. The air domain has become an unrestricted space—for war or peace, for destruction or development.

It was understood and articulated by a number of strategists in the early 1950s that unless sufficient air power is maintained, all other efforts at securing the nation would be futile. In other words, barely fifty years after its debut as a dual-use capability, air power had become an acknowledged critical element in the national security equation. Therefore, the first fundamental consideration of air power, as explained by General H. H. 'Hap' Arnold, is that, 'air power is not composed alone of the war-making components of aviation, [instead] it is the total aviation activity, civilian and military, commercial and private, potential as well as existing.' Air power is the total ability of a nation to employ its flying assets.

The second fundamental aspect emanates from the first. That is, air power is indivisible. Both military and civil air power is supported by the same national infrastructure: the runways, technically trained airmen, design and manufacture facilities, material for production, and research and developmental capabilities. As long as these basic elements are available within the nation, its capability to create national air power is not impaired. It will only take a bit of recalibration for civil aviation support to be converted to military aviation facilities. The third fundamental feature is the ability and the capacity of a nation to fly. The capacity to fly is determined by the current available national air power and the infrastructure necessary to create a potential for a further future increase in the capacity, if necessary. A nation's air power capacity requirement is a combination of its needs vis-à-vis commercial air transport capabilities and that of the military establishment, which needs to ensure the sovereignty of the nation from any possible aggression.

While the three fundamentals explained above are vital to the current national air power, the long-term potential of a nation to possess adequate air power is underpinned by a few factors that may,

at first glance, appear unconnected to air power. However, these are essential to the continued existence of a viable national air power capability. These five factors are: geography, demography, resources, industrial development and political conditions.

Geography includes global location, climate and weather and also the physical conformity of the nation. If the national territory of the nation is in one single mass, it becomes easier to develop the infrastructure that would be able to support national air power. A large national land mass is conducive to increased flying activities and the creation of potential air power. Demography and resources are interconnected. Resources encompass both economic and natural resources necessary for the construction, operation and maintenance of aircraft and support infrastructure associated with aviation. A nation that is fully reliant on imports for manufactured aircraft, and the spare parts required for their efficient operation, can be considered critically deficient in potential air power. History has shown that nations can be held to ransom in an emergency. The other aspect of resources is the raw material and fuel reserves required to establish a self-sufficient aviation industry and the capacity to operate air power assets at the nation's will. Both have a direct impact on the efficacy of national air power.

Building a stand-alone capability also requires people with the right qualifications. The demographics of a nation affects the present and, to a greater degree, the future of national air power. Essentially, the profession of aviation, the bedrock of national air power, needs to have a pool of young men and women. In the operation of highly sophisticated airborne platforms and in their manufacture, youth is a major factor. The ability of the nation to have a sufficiently large pool from which to select aviation specialists is an unavoidable requirement. Further, the educational level of the group from which selections are done is also an important factor. Aviation and related activities are an industry that requires higher overall technical and technological skill levels as compared to other industries. The demographic requirements need a fine balancing act within the nation, especially if the population pool is numerically small.

An indigenous aeronautical industry is the other factor that can make or undo a nation's air power potential. In the contemporary globalised commercial and industrial environment, the aviation industry has become concentrated in the hands of few nations. This is a drawback to national air power of middle and small powers. However, in the current international economic situation, the nations without sufficient aviation industrial capabilities will have to be dependent on the larger nations to fulfil their needs. This is where the political dimension enters the equation. Of the factors that affect the long-term development of national air power, domestic and international political status of the nation is the most important. The international relations of a nation plays an important role in assuring the availability of adequate air power, especially when the industry is concentrated in the hands of a few nations. The future development of national air power assumes a vexed position for the nations that have no capacity to develop and deploy air assets on their own. However, in the 21 century that is the bitter truth of the matter.

National air power is today the most dynamic element in a nation's strength. The fact remains that air power will continue to be a critically necessary element of national power, if the nation is to be assured of being able to protect its sovereignty. Today, without the means to control its sovereign air space, a nation remains open to aggression. A nation has to maintain the capacity to fly, there is no other option.

What Constitutes Air Power? (#300)

Key Points

- *Air power is extremely complex and has to be studied and understood as an independent and multifaceted power projection capability.*
- *Effective air power is the combined product of a large number of variable elements, each of which is critical and indispensable.*
- *A practical national approach to industrialisation is critical for the development of air power.*

A fighter aircraft providing a public display to celebrate a national day or some other occasion of significance, or the news report of an air strike against insurgents in some far away conflict often enough represent 'air power' to the general public. There has also been a tendency to equate, or at least compare, the concept of air power to that of sea power. There is only superficial commonality between the two and are simplistic attempts to understand air power. Air power is extremely complex and has to be studied and understood as an independent and multifaceted power projection capability. It is an optimised combination of a number of components, some of which are not apparent to the casual observer.

Effective air power is the combined product of a large number of disparate elements, each of which is critical and indispensable. The relative importance of each of these elements may vary, but the absence of even one could prevent the optimised exploitation of the air domain. The more important elements are airborne systems, command and control, and the ability to exploit the electronic spectrum, indigenous industry, air bases, personnel and training, strategy and planning, and intelligence.

Airborne Systems. Air power is the ability to do something in and from the air, for which control of the air is an obvious pre-requisite. Control of the air can only be achieved through having sufficient numbers of airborne systems of the necessary calibre. There has been a misconception circulated in recent times that control of the air can be achieved by surface-to-air weapon systems. This is a

fallacy. These surface-based weapons are 'air-denial' systems that can deny the use of the air domain in a clearly delineated 'time and space' and nothing more. Control of the air is a far broader concept. At the barest minimum it must be able to provide an uncontested bubble of airspace that can be superimposed over the surface and moved rapidly with the progress of the battle, which will provide one's own surface forces the necessary freedom of manoeuvre. Obviously, surface-based weapons will not provide such control. The bubble, mentioned above, is normally not sufficient and free-ranging airborne combat assets will be needed to ensure adequacy of control of the air. In addition, other airborne support systems are critical to projecting air power effectively. Essentially, three things are crucial in terms of airborne systems—quantity, quality and specialisation.

Command and control and electronics. The criticality of command and control to the efficient application of air power cannot be overemphasised. Communications are critical to effective command and control and the electro-magnetic spectrum (EMS) has become the centrepiece for the generation, sustainment and employment of air power. Reliability and adequate redundancy of communications is essential for effective application of air power. The EMS is exploited by air power for all activities that it undertakes. Therefore, uninterrupted access to the spectrum has to be ensured for air power to deliver the demanded effects.

Indigenous industry. Air power is the product of technology and it is continuously being refined through technological innovations. While an indigenous aviation industry would be a 'good-to-have' capability, in the contemporary world, even middle-power nations will not be able to afford a self-supporting industry. The costs involved are far too high for any other than a few nations to afford. In this situation of increasing importance of technology, nations that aspire to maintain a viable air power capability must have the infrastructure necessary to accept and operate high-end technology that is vital to air power. The indigenous industry must be kept at the leading edge of technology, which in itself becomes a function of the national education base and the emphasis placed on scientific innovation in education and industry by the government. It must be noted that even a limited degree of industrial capability requires an appropriate availability level of raw

materials. Air power, unfortunately, cannot be sustained by the mere importation of systems.

Air bases. Without a network of mutually supporting bases, with the necessary infrastructure, it will be impossible to apply air power. These bases in turn must have their own support networks—through access to ports and commercial hubs—to ensure an adequate supply of bulk goods such as fuel and ammunition. From a strategic perspective of national security, the geographical location of the bases also assume importance. The location of bases would have a direct impact on the selection of the airborne weapons systems as well as on the doctrine, strategy and concept of operations. The air bases also need protection since they are the nests where the offensive capabilities of air power are developed and nurtured.

Personnel and training. The personnel requirements to project power through the air is fairly high. Even though 'uninhabited' systems are becoming increasingly more effective, the number of people required to support, maintain and operate them efficiently is as many as required for inhabited systems. From a combat application point of view, the numbers required have not changed in the past few decades. In fact the technological sophistication of modern airborne systems demands a larger number of highly trained support personnel. This demand increases the training requirements in terms of both time and educational requirements. The importance and requirement for adequate training is often overlooked, especially in discussions of air power in the public domain.

Strategy and planning. The success or otherwise of the employment of air power is directly influenced by the development of strategy and also the deliberate planning that is done before the actual outbreak of hostilities. The application of air power is influenced, directly and indirectly, by a large number of factors. They have to be taken into account in the planning of the air campaign, a process that can be ignored only at the peril of failure. Air power can only be applied effectively if it is done within the broad strategy that is effective. Even the best air power capability will be of little use if it is employed within the ambit of a faulty strategy. Planning and strategy are the two foundational pillars upon which the elevated status of air power is built.

Intelligence. Situational awareness is the key to effectiveness in battle and is equally true for the application of air power. However,

air power has the inherent capacity to gather and synthesise data to create what could be termed 'actionable' intelligence, in much greater detail and more rapidly than other domain-centric military forces. Intelligence, gathered by airborne assets and then disseminated as required forms the basis of planning and operations. This is fundamental for the application of air power.

There are other elements such as morale, logistics, research and some support services that constitute the holistic concept of air power. Even with the necessary constituents being made available, there is an intangible factor in developing and maintaining air power with the necessary staying power—the ability of the nation to evolve a sustainable 'industrialised life' for its citizens. This is so because air power is inherently a technology-enabled capability. Air power is influenced by a number of elements that are variable and can neither be exactly determined nor fully controlled. A nation that does not have a clear understanding of these variables and an appreciation of the elements that constitute air power will fail to take advantage of the enormous potential that air power brings.

The Demands On Air Power And Its Doctrine (#301)

Key Points

- *Air power has always provided capabilities that complement, and at times substitute for, those of the surface forces.*
- *The ability of air power to be an 'envelope force' that is not constrained by terrain or geography, has made it the first instrument of choice for governments.*
- *The foundation to meeting the demands placed on air power is a doctrine that retains the flexibility to adapt rapidly to changing circumstances and strategic considerations in the application of air power.*

There can be no doubt that the strategic security outlook today is far more complex and uncertain than it was even a decade ago. The emergence of non-state entities with sufficient military power to contest control of the battlespace against the strongest of conventional forces and the upheavals to the international political landscape that this development has introduced show no signs of stabilising. On the other hand, the world has become increasingly interdependent where regional changes and challenges routinely trigger global effects.

While the need to wage a conventional war will continue to remain, the relative importance of irregular warfare—conducted to contain and prevent the escalation of activities by non-state, terrorist and insurgent groups—is set to continue to grow. In this confused and complex future, there is an appreciable trend to move warfighting towards irregular wars, which has its own unique characteristics and particular methods of conduct. What role then does air power play in this scenario?

Before, analysing the role that air power plays and the evolving nature of air warfare, it is necessary to state clearly that now, and into

the future, all forms of military action will be joint in their planning and conduct. While this tenet is universally accepted, the challenge in putting the concept into practice is in understanding 'who supports whom' and the contextual manner in which the 'supporting' and 'supported' elements change. In joint operations, the days when air power was treated as a support arm for surface forces have long since passed.

In fact, air power has always provided capabilities that complement, and at times substitute for, those of the surface forces. Far more than even a few decades back, modern military air power and its employment has been a multi-Service capability. Air power is no longer resident solely in air forces. This is amply demonstrated by the fact that the US Navy air arm is ranked fifth, in terms of its size among the air forces of the world. Further, 'air forces' also comprise all elements that directly affect flying operations such as surface-to-air defences. In this case, the command and control of such assets may rest with the air force or where necessary the army/navy.

Future military campaigns will be joint in nature with the land, maritime and air forces contributing. However, the individual contributions will not always be equal—different strategic and operational situations will demand different lead elements identified from within the three domain-centric Services. This delineation of 'supported' and 'supporting' is vital for the success of any joint campaign. Historically, the lead element was determined by the geography of the theatre of operations. The advent of air power as a military capability changed this concept irrevocably. Now the lead element is determined by focusing on the effects that have to be created, the force structure of the joint force and the spread of the theatre, both geographic and virtual.

The ability of air power to be an 'envelope force' that is not constrained by terrain or geography, has made it a front-runner in being the first instrument of choice for governments, not only for the projection of lethal power at short notice but also in instances of war-prevention and peace enforcement. This assertion is made with the support of two

key factors. Firstly, air power's inherent characteristics—reach, speed, responsiveness, flexibility—makes it ideally suited to overcome the challenge of geography that is felt by surface forces. Further, enabled by technology, air power can exploit the third dimension to concentrate force, in a way never possible before, which supports strategies aimed at diffusing rapidly evolving strategic and operational situations in the battlespace. Secondly, the political aversion to casualties, of both friend and foe, makes air power the ideal capability to be deployed to contain emerging situations. Although more resource-intensive, the risk of casualties is minimised because of the precision, discrimination and proportionality that the application of air power inherently brings to the fight.

The military campaigns and the conduct of air warfare within them in the past four or five decades have clearly indicated an unmistakable trend. These campaigns have demonstrated that air forces—meaning the air power assets and the capabilities of the military force irrespective of the Service that owns them—are quick and relatively easy to insert and extract, involve only limited political commitment and, as a result, offer fewer liabilities in attempting to resolve a crisis. These reasons indicate that air power will unavoidably be required to play an increasing part in all future conflicts.

The demands on air power, in the years ahead, are likely to increase at a rate not witnessed earlier. The challenge facing professional airmen can be distilled into a single element: to ensure that the doctrine that guides the employment of air power is rigorous and permits the full exploitation of air power's considerable capabilities. In ensuring the veracity of its doctrine, air forces must take into account three key factors: strategy, organisation and technology.

The expanding capabilities of air power have obviously also increased the strategic options that it brings to planners and decision-makers. One of the key options relates to information warfare, primarily aimed at reducing the adversary's ability to make timely and well-informed decisions, while ensuring that one's own information flow, its speed, quality and quantity are preserved. Essentially this supports the concept

of striking at the adversary's ability to wage war. The application of air power is now passing through a phase where the validity of the strategy of 'parallel operations' is giving way to one of 'integrated asymmetric operations', which seems to be more suited to the irregular wars that Western military forces are engaged in at present. The evolution in air warfare is visible.

Air power remains a limited resource. At the core of the application of air power sits the principle of unity of command that in turn leads to the recently adopted tenet of centralised command, decentralised execution and distributed co-ordination. To provide the air force with the ability to exploit this concept, it needs to have the right organisation. Unity of command can only be ensured by an organisation that is live and capable of extreme flexibility since air power itself is evolving in diverse—and at times unpredictable—ways very rapidly.

Technology is the mainstay of cutting edge air power and its interaction with doctrine is much more pronounced in air power than in the case of either land or sea forces. In the case of air power, doctrine defines how forces can best be developed and employed while technology determines the extent to which the aspirations can be realised. However, today rapid technological developments provide a range of options that normally surpass the doctrinal demands.

Since its inception air power has continued to meet the demands placed on it through developing employment strategies that optimise available capabilities; creating and continually fine-tuning an organisation that is uniquely tailored to the changing demands of a force that is in the forefront of national power projection; and adapting technological innovations to improve its operational efficacy. The foundation to meeting these basic demands placed on air power is a doctrine that retains the flexibility to adapt rapidly to changing circumstances and strategic considerations in the application of air power through evolving concepts of operations.

The Centrality Of Air Power: Still A Contested Concept? (#303)

Key Points

- *A little over a century from the beginning of the 'air age,' air power has matured into a powerful component within the elements of national power.*
- *The lack of an acceptable definition of air power, mainly because of its dynamic nature, has created debates and discussions regarding the ownership of air power at various times.*
- *Air power's value to the nation is directly related to what it can do, rather than on its definition.*

Air power provides highly versatile and effective tools that are capable of enforcing national strategy, which in turn ensures the security of the nation. More than a century from the beginning of the 'air age', air power has also matured into being a powerful component within the elements of national power. These are incontestable facts. However, even as the concept of the employment of air power, especially in its lethal mode, has matured and proven itself, there is still a lingering uncertainty at times regarding its efficacy. The narrative of air power, its theories and practices, its demonstrated effectiveness in conflicts of the past few decades, this questioning of air power and its position in the hierarchy of national power continues to make it controversial.

To the people whose knowledge about air power is limited, the nuances of the features that together make up a whole that is termed air power is difficult to fathom. This difficulty is exacerbated by the fact that of all power projection capabilities resident within a nation, strategic air power is the most dynamic—in its theory as well as employment. Air power's dynamism is at once its unequalled strength as well as the single most important contributor to the controversy that surrounds it. The air power narrative, at the strategic and conceptual levels, is never at a standstill but always changing in its character while the fundamental nature remains a constant. Air

power continues to be controversial. There are few factors such as its definition, its primacy in military intervention campaigns, and its role as the enveloping force in joint campaigns that ensure its centrality in joint campaigns and yet make it a contested element of national power.

Since air power is an instrument of national policy, its contribution cannot be separated from political intentions and objectives. Air power, or for that matter any other element of national power, therefore becomes a part of the political process. In fact the entire history of air power has been overwhelmingly influenced by political intentions and consequences. The process of defining air power itself demonstrates this complexity of its historical development and the inherent controversy that it generates. Further, the success of air power in achieving its objectives has also inhibited the acceptance of a concise and common definition, making the available definitions contextual and catering to the circumstances of a particular nation.

The many definitions that are available—almost all of them apparently correct within the circumstances of their development—also feed the misperceptions that abound regarding understanding, employing and commanding air power. The continuing debate regarding the military ownership of air power, prevalent in almost all nations that possess a military force of some calibre, is a tribute to the fact that air power is a capability that is critical to the success of military operations. From that foundational understanding stems the craving to control its assets. Again the situation becomes blurred because of the less than optimum understanding of the different aspects of the generation, application and sustainment of air power. It is one thing to know that air power is vital to military success, but a completely different ability to be able to command it effectively. A definition that attempts to answer all these questions is difficult to craft and therefore the contextual ones will have to suffice. As long as the definition of air power remains open there will always be a contextualised contest regarding its ownership and employment.

In the contemporary global security environment, military intervention in areas of instability is becoming more common and

a regular occurrence. This is perhaps the downside of globalisation, because no nation, however stable, can be assured that burgeoning instability in one region will not spill over into its own backyard. The Middle-Eastern wave of migration into Europe in the recent past is a classic example. In any such intervention, air power has become the force of first-choice to be employed. The reasons are equally political as it is based on the strength of air power.

While military interventions in volatile regions of the world have become a necessity, the political leadership of the intervening nations is also sensitive to their own casualties. The method to keep the risk of casualties minimised is to employ air power extensively, while not deploying ground forces at all or keeping ground incursion to the barest minimum. This operational concept is seen to work well in most of the current intervention situations, where the adversary does not possess credible air power capabilities. In other words, the airspace is uncontested and risk of casualties is almost non-existent. The strategic, operational and technical dynamism inherent in air power makes it an effective power in these circumstances.

This switch in roles where the army is only used in the background, especially in the more common place irregular wars, creates a rift between the advocates of air power and those strategists who support the traditional 'boots-on-the-ground' approach. The use of air power as an independent entity becomes the target for deliberate misunderstanding of its capacity to create the necessary effects to ensure success. The centrality of air power to military success has made it a contested capability. Flowing from this is the demand for air power, as defined by the critics, to be placed as an element of the 'military forces', which invariably means the army.

The requirement is for military forces to function as joint forces to achieve national security objectives that are politically defined. There can be no debate regarding the relative value of strategic air power, land power or naval power in this security equation. The fact is that each of these capabilities will be employed situationally and will vary with the context. Extraneous factors like a nation's attrition tolerance and

the ethos of its population will always impinge on the employment of military forces. These forces will carry more weight in discussions when the intervention, conflict or war is seen as one of 'choice' rather than 'necessity'.

Air power's value to national security—at all levels from the strategic to the tactical—is completely dependent on what it can do and the effects it can create, not necessarily what it is defined as, whether contextually or in a very broad manner. Air power, being a strategic asset, can be converted to a tactical apparatus of very limited impact by its employment and concepts of operation being developed to achieve narrow objectives. Modern warfare, whether irregular or conventional, demands that it be conducted as a whole. Even so, a lot of jointness is always left to be desired, let alone achieving seamless integration that developed military forces have started to mention. In spite of a great deal of study and development, the geographical boundaries that define capability spectrums of the three main components of the military force—army, navy and air force—continue to draw clear dividing lines. Air power, with its ability to envelope the other two domains, has to assume the role of the integrator. Contesting this concept or challenging the ownership of air power is not the answer to efficient joint operations.

Force Packaging For Power Projection (#306)

Key Points

- *The role of the military forces has evolved from employment to protect the geographic boundaries of the nation to a broad sweep of activities aimed at projecting power to protect national interests.*
- *The effectiveness of force projection is dependent on three major factors—time available, balance of capabilities in the force and ability to sustain the projection.*
- *The RAAF has demonstrated its ability to provide an air power package that can project power in an expeditionary mode for the duration required.*

Some truisms: The military forces of a nation are primarily meant to defend the sovereignty of the state, ensure national security and protect national interests. In the current international system, military forces are the agents that a sovereign government can legally direct to employ lethal force outside the state in the pursuit of legitimate ends. However, since the end of the Cold War, the role of the military forces has evolved from a focused employment to protect the geographic boundaries of the nation or the projection of national power toward a broader sweep of activities aimed at projecting power in order to protect national interests, wherever they may appear to have been compromised.

Until the advent of digital high speed communications, power projection had been associated with military forces. However, in recent times other elements of national power, such as economic, diplomatic and informational power, are also being employed as instruments for power projection, based on the use of digital media. While these, mostly soft power elements, can be used as tools of coercion, they cannot be used to fully enforce the will of one nation on another. Military forces continue to be the element of national power that can be legitimately used

to enforce the will of the nation, if necessary through the application of lethal force. At the high end of national security strategies, a nation's force projection capabilities are primarily resident in its military forces.

The cycle of strategies that ensure national security starts at the benign level of influence and shaping, then progresses to deterrence and then moves to coercion and goes on to punishment and destruction. In this cycle, non-military force projection capabilities can only play an effective role in the strategy of influence and shape and a much more diminished role in coercion. On the other hand the military forces will play a critical role in force projection within the entire cycle of strategies.

The effectiveness of force projection is dependent on three major factors—time available, balance of capabilities in the force and ability to sustain the projection of force. In this discussion extraneous factors such as the political and national will to employ the force package and the resource availability to build the force to the required standards are being considered as available as necessary.

There are two further aspects regarding relative time in terms of force projection. First is the time available for a nation to respond to an emerging challenge and second, the rapidity with which a force package can be assembled and deployed. In the contemporary security scenario it is inevitable that time available to respond will be short and therefore the military force will have to rely on rapid deployment. In turn this would mean that military forces would have to be kept at some level of readiness to respond.

Ascertaining the balance of capabilities to project force at the appropriate level to ensure that the emerging challenge is contained is a complex process. The elements of capabilities that can be incorporated within a force projection package will depend on the overall structure of the military force. Similarly the ability of the force to sustain the package for the necessary duration will also be a critical factor in ascertaining the viability of the package.

The factor of relative time available will superimpose itself on the development of the capability spread of the package and could very often act as a constraint. This statement has to be understood with few caveats.

Air power will be at the vanguard in situations that require rapid kinetic responses. However, there is a complex interplay of hard and soft power, kinetic and non-kinetic response, as well as a balanced combination of military and non-military national power that go towards creating a viable power projection package. The combination of the need for a rapid response and the balance of capabilities necessary to ensure the practicality of projecting power will point towards the employment of air power within an integrated package of military power as the initial response to force projection requirements.

From a purely air power perspective, this situation warrants an examination of the capability spread required within an air power package that can, along with other elements of national power, project power in an effective manner. While every such package would have limitations in terms of time and projection capabilities, the first requirement would be to have all elements of air power embedded in it. This would mean having the ability to create control of the air where and when required, the capability to carry out accurate, proportionate and discriminative strikes to create the necessary effects, airlift of sufficient quantity to sustain the package in an expeditionary mode and sufficient intelligence, surveillance and reconnaissance (ISR) capabilities to ensure adequacy of information. These capabilities would also have to be supplemented by self-sufficiency in electronic warfare (EW), command and control infrastructure and air-to-air refuelling capabilities.

The most important factor that will determine the effectiveness of an air power package is its relativity as part of an integrated national solution to an emerging security challenge. Once it has been ensured that the air power package is essentially integrated into the broader power projection capability of the military and the nation, the other factors peculiar to air power can be distinguished and examined.

Two factors would determine the effectiveness of such an air power package—its range and sustaining power. The range in this case need not be the geographical distance that the package can travel, but the reach that it has in terms of targeting capability. In turn, the targeting capability would be a function of the ISR element within the package. Considering the weapon

envelope and EW capacity, the targeting reach will or should always be more than the force package range. The ability to target at a distance from the physical position of the air power package is a prized competence and could be the critical element in strike operations.

The sustaining power of an air power package is directly proportional to the availability of air mobility assets as well as the critical mass of other capability delivery systems. From an air force perspective being able to create an air power projection package is a complex enterprise. First, the air force in question needs to have the full suite of capabilities that make it a balanced force. Second, and perhaps more importantly, it needs to have developed a versatile command and control structure that permits the functioning of an air power package as an independent entity, with sufficiently robust remote governance oversight. Third, the force should have developed and exercised concepts of operations that fit into the broader joint campaign, even while the independent air power package is operating. The requirement would be to function autonomously, but within the larger joint campaign and its objectives.

In the current environment there are only few air forces that can fulfil the above requirements of having the complete suite of capabilities; being able to effectively put together a force projection package; and being able to deploy the package to the necessary theatre and for the duration required. Versatile command and control and ISR capabilities that greatly increase the horizon of the force projection package are premium capabilities that are not easy to obtain and even more difficult to maintain as part of a much larger package. In this context, the RAAF has demonstrated its ability to provide such an air power package and operate it in an expeditionary mode, as required. Amongst the middle powers of the world, this is a unique achievement and is a reflection of the professionalism of the members of the Air Force.

The Intellectual Underpinnings of Air Power (#308)

Air power burst into the realm of military power projection capabilities only a century ago. Its rise to prominence and the current pre-eminent position that it occupies within the ambit of national security has been nothing short of phenomenal. The rapid rise in air power capabilities, proliferation of concepts and growing operational success has, however, created its share of challenges and drawbacks. The strategic concepts underpinning the employment of air power were developed in between the World Wars and were based on speculative thinking rather than on historical analysis, since there was no 'history' to fall back on. This situation required harnessing the intellectual potential of technically proficient airmen for them to become professional masters of air power.

Key Points

- *Air power should be employed to produce decisive strategic effects to achieve national objectives, while still being part of a joint force.*
- *The key concept of an effects-based approach to the application of air power has not been sufficiently refined or developed as an overarching strategy.*
- *The lack of deep-seated and long-standing analytical processes and academic background are visible gaps in the intellectual development of air forces.*

In World War II, air power was employed based on unproven theories in two distinctively different ways. First was the strategic bombing model that promised strategic success through attacks on the enemy hinterland without having to confront the adversary's army or navy. The second was the ground-centric model that saw air power as yet another technology-enabled tool to support traditional land or maritime campaigns. The advent of the atomic bomb and the emergence of the Cold War brought about a change in air power thinking, based on the concepts developed by

political scientists—deterrence, massive retaliation and mutually assured destruction.

Subsequently, the Vietnam War and other minor conflicts leading up to the 1991 Gulf War, saw the emergence of the 'air-land' doctrinal and conceptual focus. This development emphasised the tactical and operational level aspects of the application of air power—stressing the support for the war on the ground—almost completely ignoring the conventional and direct use of air power to create longer-term strategic effects. This situation even influenced the common understanding of John Warden's famous rings. The debate whether air power should be applied against ground targets as support to the land war or employed against targets that would produce decisive strategic effects, continues to this day. However, the 1991 Gulf War was also the starting point for laying a set of new conceptual foundations for the employment of air power.

The visible effects of the application of strategic air power in the 1991 Gulf War—Operation Desert Storm—unequivocally established air power as a strategic element of national power. This move to the vanguard of power projection capabilities was accompanied by a common perception, especially amongst the political leadership, that air power alone could win wars while limiting own casualties. The perception that, though the application of air power, wars could be fought, and won, in a relatively cost-effective, risk-free and bloodless manner skewed the understanding of the importance of air power and the effects it could create, at the strategic political level of national security. As a result, the key concept of an effects-based approach to the application of air power was not sufficiently refined or developed as an overarching strategy.

The campaigns to alter the leadership's behaviour, Bosnia(1995) and Kosovo (1999), turned air power into a coercive instrument, and in the eyes of some air power enthusiasts, proved that the lethal application of air power as a war-winning strategy. It reinforced and perhaps entrenched the concept that air power should ideally be used as a strategic instrument and if employed 'correctly' could win wars on their own. This is a contestable, if not wrong, assertion. The 1991 Gulf War or the campaigns in Bosnia and Kosovo did not change the reality of the failings of the conceptual development of

air power. While they were all clearly satisfying campaigns for the air power supporters, they did not, in actuality, prove their fanciful claims, nor did they point towards air power becoming an independent war-winning force. Just the opposite.

The insurgencies of Iraq and Afghanistan in the 21st century clearly demolished the myths that were being built around the efficacy of air power after its successes in the last decade of the 20th century. The fact was that these air campaigns were not adequately analysed with sufficient intellectual rigour in order to develop a strategic approach to the application of air power that could cater for the broad variety of conflicts and contingencies that bedevil the military planner. This lack of intellectual approach to carrying out an in-depth analysis of successful as well as unsuccessful air campaigns has been a long-standing challenge for the 'correct' conceptual development to ensure the efficient application of air power.

The breakneck speed of air power's technology-enabled development has led to air power attracting action-oriented operators or 'doers', to the exclusion of persons—best described as 'thinkers'—motivated by intellectual curiosity and/or well-versed in analytical and academic disciplines. This is not to say that the airmen adept at operations do not possess analytical inquisitiveness or academic qualifications. It only indicates that purely because of the sophistication of their professional competency and the intensity of dedication to the 'art of combat' necessary to excel in that sphere, airmen are not instinctively inclined to pursue proficiency in the study, understanding and critical analysis—all intensely intellectual activities—of air power and its direct connection to the grand strategy of the nation.

By virtue of their being operators, they also tend to be at the lead of creating and delivering air power. This is further emphasised as the result of the visible complexity in the delivery of air power—through its entire spectrum, from benign employment to lethal application—being considered the responsibility of the flying fraternity. Further, air power was born and baptised by fire in World War I, and saw the step-change functions in its capability being encapsulated during World War II and subsequent wars. Air power's capabilities are most visibly demonstrated in times of war. In war, leadership of a fighting force is, more often than not and rightly, delegated

to a combatant, a 'warrior', in the case of air power, the operator. In relatively recent times as the employment of uninhabited combat aerial vehicles have come into common usage, the application of air power continues to be undertaken by operators. Therefore, it is not surprising that operators have been air power leaders, perhaps by default, in air forces across the world. (In this *Pathfinder*, the moral challenges and ethical issues of leadership of combat forces are not discussed.)

The fact that operators have predominantly been leading air power has also harboured one of the major drawbacks in creating a holistic understanding of air power and its myriad capabilities. The nuances of air power's employment, how it transcends from the operational to the military strategic and through it, to the national security and political arena, and the political effects that it can create at the grand strategic level have all been pushed to the background because of a lack of deep-seated and long-standing analytical processes and academic development within air forces. From their very inception and for far too long, air power generating and sustaining organisations—essentially the air forces of sovereign nations—have been focused on the tactics, procedures and operational planning that combine to make the application of air power immensely successful. In the bargain, air forces as institutions, have not produced an adequate number of intellectually astute air power professionals who while being adept at its operational level application, can as easily transcend to the strategic level of its employment aimed at achieving national objectives. The institutional culture in air forces has not so far been conducive to the creation of structures and in-house institutions oriented towards and best suited to analyse and plan the application of air power in the complex spread of the broad spectrum of possible contingencies at the Grand Strategic level. This is a visible gap in the professional capacity of airmen that can only be filled by the development of men and women who are intellectually curious and academically qualified, while still retaining the capability to 'operate' the systems to their optimum.

The Concept of Military Transformation Key to Seamless Integration of Forces (#310)

Key Points

- *The transformation concept is a critical element in preparing the military to meet emerging threats and future challenges.*
- *The concept of transformational change permits the adaptation of high-technology capabilities to be effective in smaller irregular wars.*
- *Transformational change ensures that a military force achieves rapid, high-technology enabled battlefield victory, that is aligned to strategic objectives dictated by national security imperatives.*

The concept of military transformation is closely linked to the ongoing Revolution in Military Affairs (RMA), a process that aims to exploit the dramatic and exponential developments in the field of military technology to create unparalleled advantages over possible adversaries. The concept of transformational change has been one of the foundations for the development of military power for the past three decades. In fact, the ability of military forces to transform themselves rapidly has been the key factor in ensuring that they have been able to achieve the desired end-state in all the conflicts since the end of the Cold War. However, the concept of transformation continues to remain amorphous, and therefore complex.

The transformation concept not only ensures the optimisation of the performance of the forces but is a critical element in preparing the military to meet emerging threats and future challenges. While its criticality to military success is accepted through many analyses, it still remains an undefined concept. This in turn makes measuring its exact contribution to the success of military operations equally vague. Perhaps because of the ambiguous status of transformation, its importance has not been fully appreciated

in the broader military strategic thought and tenets. Although not easy to define, a US Department of Defence policy brief from September 2003, Technology, Transformation and New Operational Concepts, defined the concept as:

> *A process that shapes the changing nature of military competition and cooperation through new combinations of concepts, capabilities, people and organisations that exploit our nation's advantages and protect against out asymmetrical vulnerabilities to sustain our strategic position, which helps underpin peace and stability in the world.*

While all military capabilities have been influenced by RMA, this *Pathfinder* looks at the impact of transformational change on the development, application and sustainment of air power. It must also be noted that RMA influences and affects different military capabilities in different ways and to different levels, dependent on their reliance on technology for their optimised employment. In this respect, air power has a unique relationship with RMA, since it is completely reliant on technology. To derive the maximum benefit from the on-going process, it is necessary to ensure that the RMA and the transformational change that it brings about is comprehensively accepted and requires the adaptation of all aspects of air power—organisation, force structure, doctrine and capability development.

The 1991 Gulf War was the first example of an ongoing RMA (it could also be considered *the* RMA, in many ways) and became the fundamental source for the subsequent transformation that took place in all aspects leading to the employment of air power. The reliance on, and uninhibited use of, computer and satellite-enabled networks in combination with Precision-Guided Munitions transformed the application of air power and the strategic effects that it could generate with ease. This transformation granted air power an unprecedented capability to identify, locate, track and neutralise chosen targets. Immediately after the 1991 Gulf War, air power capability and its

application were fine-tuned, and the next step in the transformational change with respect to warfighting was instituted. The next step was to link the platforms and systems of individual services into a common network in order to maximise and focus the effects the joint force could produce.

The concept of transformational change, especially in respect of air power, provides the wherewithal to adapt the capabilities meant to fight and prevail in a high-tech state-on-state war to be effective in smaller irregular wars, which have different characteristics and trends. Further, transformation, could in certain circumstances, compensate the lack of quantity through the creation of superior quality of competence, capability and efficiency. In other words, air power has been able to replace mass with the creation of focused effects to achieve the same strategic objectives. While air power could be considered to have been the first element to embrace and demonstrate this somewhat radical concept, both land and maritime power practitioners were quick to follow suit. Early in the 21st century, transformational change permitted not only the conduct of effective joint operations, but also provided the military forces to reduce the size of the fighting component while successfully increasing their fighting power and effectiveness.

In the contemporary global security scenario, the more developed nations of the world have been compelled to deploy their military forces to undertake nation-building and stability operations. Only by embracing the concept of transformational change have the military forces been able to move away from their 'Big-War' orientation and adapt to the vagaries of asymmetric and other irregular war phenomena. However, this success has come about only because of considerable intellectual and institutional effort at all levels of decision making—starting at the strategic and flowing seamlessly down through the operational into the tactical.

At the strategic level, transformation also has a direct connection to national security. This connection is far more apparent when the nation has a proclivity to employ military forces in the pursuit of national security objectives. In the current international security

environment, air power as part of a joint force, could be called upon to undertake a breadth of missions and also to be at the vanguard of military power projection. Considering the low chances of needing to fight a major state-on-state conflict, transformational change will be the foundation on which the successful employment of air power will rest. The demonstrated efficacy of air power in irregular wars in the past two decades is testimony to the concept of transformation. Transformational change is aimed at ensuring that the military force achieves a rapid, high-technology enabled battlefield victory, which is aligned with the strategic objectives as dictated by national security imperatives.

On the one hand, successfully implementing the concept of transformational change is neither an easy task, nor is it within the capability spectrum of all military forces. On the other hand, air power is particularly attuned to accepting transformation, especially since air power as an entity within the spread of military capabilities, shares a close relationship with cutting-edge technology. In the contemporary world, where military forces function as a joint force and the effort is to achieve seamless integration of the three fundamental domain-delineated power projection capabilities, air power has the ability to lead the transformational change required to achieve national objectives. Transformation brings about the conduct of a campaign based on a common battle picture and situational awareness. The goal of seamless integration of a joint force can only be achieved through adopting and adapting transformational change. The concept of transformation, while still a complex and ambiguous process continues to underpin the efforts of military forces to become an integrated entity.

The Inherent Jointness of Air Power (#313)

Key Points

- *The first military role undertaken by air power was 'observation' for the land forces, which was an inherently joint endeavour*
- *The air campaign to control the air is as joint as any other campaign and fundamentally meant to provide freedom of manoeuvre to the surface forces*
- *During the past century, the use of air power to provide fire support to ground forces has become a corner-stone of joint operations*

Air power can no longer claim to be the youngest sibling in a triumvirate of military capabilities. Modern military forces have already ventured into domains that were in the realm of science fiction just a few decades back. Space and cyber have now become entrenched as domains in, and through, which 'attacks' are carried out by adversaries. Accordingly, nations attempt to protect themselves from these attacks by creating both defensive and offensive capabilities in all five domains. Of the five domains, four are physical domains and only cyber remains a virtual one, with its own unique characteristics. Although space is a physical domain, internationally there is at least an overt reluctance to accept that the domain has been militarised. This leaves the three traditional domains for the military forces to develop means to dominate, both in times of relative peace and during war.

A nation's ability to physically project power at will continues to be predominated by land, maritime and air power capabilities. Other elements and factors will contribute to the employment of these capabilities in an optimum manner, although these extraneous factors will remain at the periphery of power projection. Over centuries of the application of force, military forces have learned that success in operations is easiest to achieve when the force is employed in a joint manner. Joint, in this case, does not mean that the three domain-centric warfighting

capabilities are subsumed into a single homogenous entity; it means that the three independent capabilities are moulded in a contextual manner to achieve the operational objectives of the task force. The ratio in which the different capabilities come together will always be a function of the situation, contingency and context in which power is being projected and the desired military end-state.

Land and maritime forces have a long history of warfighting, whereas air power has a relatively short history to back its conceptual development. History also provides numerous examples of both land and maritime power being utilised individually to wage war and prevail over an enemy, and to protect the sovereignty of the nation. Arguably, the concept of jointness between these two dominant warfighting capabilities was not a consideration in military thinking and strategies until well into the 20th century. So what changed? What was the catalyst that probed military thinkers to come up with this idea of 'jointness'? It can be argued that the advent of air power as a military capability was the headline event that brought about discussions and analysis of the concept of jointness in military operations.

The figure given above (published in the Joint Studies Paper Series 2, *The Four Aspects of Joint: A Model for Comparatively Evaluating the Extent of Jointness in Armed Forces* by Aaron P. Jackson, Canberra, 2018. p.14) reflects the arguments put forward in this Pathfinder regarding the need felt by land and maritime forces to embrace 'jointness' at the advent of air power as an integral part of military power projection capabilities.

Both land and maritime power are functional in physically separated domains. Although air power also functions in a different domain, it envelopes both the other domains and can be brought to bear directly on either of them. During World War I, air power was employed over the land domain. The experiments with naval aviation in the early days of air power is being consciously omitted from this discussion. The first role that air power performed is that of observation, to facilitate the manoeuvre of the army. This was also the first 'joint' role that was undertaken by two domain-centric capabilities. Today, control of the air is accepted as the raison d'etre for air force operations. However, it would

be well worth remembering that this role came about because it became necessary to deny airspace to the enemy to ensure the protection of the observation balloons from marauding 'fighter' aircraft of the adversary. This was the first step in the development of the joint concept.

The idea of attacking ground forces from the air was also conceptualised during World War I. While the actual capability of aircraft during this time was limited and therefore could not deliver the effects that the concepts promised, the concept of air-to-ground strikes was steeped in jointness. During the past century, the use of air power to provide fire power to the ground forces has not only become a cornerstone of joint operations, but at times also led to acrimonious debates regarding the 'ownership' and command and control of air assets. The fact remains that from its very inception, air power has been joined at the hip with land power. Along with the arrival of air power, jointness could not be denied.

Air power is an envelope capability, since it covers the other two basic physical domains without needing to be divided. It follows that the application of air power will therefore have to be seamless and unified, catering to the needs of the other domains. In other words, air power from its inception as a military capability has been inherently joint in nature.

As the concept of operations from, and in, the air developed, air power strategists realised that there was a need to carry out a campaign to obtain and maintain control of the air to the required degree so that surface operations—both land and maritime—could be conducted without enemy interference. This air superiority campaign is not often 'visible' to the land and maritime forces and therefore a myth of the air force fighting a war of its own has evolved. Nothing could be further from the truth. The air campaign to control the air is as joint as any other campaign and fundamentally meant to provide freedom of manoeuvre to the surface forces.

The clear distinction between strategic strikes and traditional interdiction strikes has somewhat blurred in recent times. Strategic strikes are meant to diminish the adversary's war-making and war-

fighting capabilities so that one's own land and maritime forces can prevail in battle, campaign and war more easily. An examination of air power's contribution to a conflict demonstrates the jointness of the application of air power in all contexts. From the strategic level to the tactical, air power is aligned to meet joint objectives.

Of all the power projection capabilities, only air power has been consciously joint from its very inception. In its infancy, the capabilities resident in air power systems were not technologically developed enough to deliver on the promises that were made by visionaries who conceptualised its forward trajectory. In a little over a century, these promises have been delivered and air power has established its truly joint credentials, across the entire spectrum of conflict. In the contemporary world, there can be no doubt that air power functions as an essential element within a joint force.

Domain-Centric Professional Mastery: The Foundation of an Integrated Military Force (#318)

Key Points

- *In the past few decades, the changing characteristics and conduct of war have created an undeniable need for the military forces to function in a 'joint' manner.*
- *Time and again it has been proven that joint operations provide the most effective way to create the necessary effects to achieve the desired national objectives.*
- *Domain-centric professional mastery is a foundational requirement for a military force to become truly integrated.*

Military forces have been tracing a path of evolution throughout history. They have gone from being purely land based fighting elements in prehistoric times, to the addition of maritime warfighting capabilities and, a little over a century ago, accepted the arrival of military capabilities based in the air domain. It took a very long evolutionary period for this triumvirate of military capabilities to develop and mature into coherent capabilities with distinctive characteristics. The evolution of military forces in the three distinct physical domains has occured at a steady and appreciable rate of progress.

In the past few decades, strategy, technology and concepts of operations have combined with the changing characteristics and conduct of war to create an undeniably accepted need for the military forces to function in a 'joint' manner. This change in the rudimentary basis of the employment of military forces did not come as a sudden revelation, but was the result of understanding hard-learned lessons from successful as well as disastrous operations and campaigns. Accordingly, the evolution in the development of military forces gathered speed and the rate of change was far greater than in the past. Joint military operations, the

hallmark of competent military forces for the past several decades, are inherently complex to plan and execute. However, the effects that are created by a joint operation far outweighs those that can be created by a single-domain force under the same circumstances.

The need to conduct joint operations brought to the fore the multifaceted nature of the command and control structure that is necessary to be activated in order to achieve the desired effect optimally. Joint operations also highlight the less than optimum understanding that the different domain-centric Services had of each other's capabilities, strengths and weaknesses. These two issues were recognised as the fundamental challenges to be addressed and ameliorated in order to ensure that the advantages that accrue with joint operations can be harnessed effectively. It was also felt that efficiently conducted joint operations would put less strain on the military forces.

Prior to the advent of air power as an element within the military forces of a nation, the compulsive need to conduct joint operations to ensure optimum efficiency was not very high. Air power, by its very characteristic of being an 'envelope element' makes it imperative for military forces to be joint in their application. Time and again it has been proven that joint operations provide the most effective way to create the necessary effects to achieve laid down objectives. In recent times, modern military forces have adapted the concept of joint operations to create an even better force, by attempting to integrate the three different domain-centric elements into a holistic force, tailored for a particular mission, campaign or operation. The application of this adaptation is still in its infancy and has a number of challenges to overcome.

So, how is an integrated force created? What are the fundamental building blocks that a joint force must have before it aspires to become an integrated force? The answers to these questions are complex, as will be the transition of a joint force to an integrated force. The basic requirement will be for a military force to have achieved truly joint status and capabilities before integration can be contemplated. This itself is easier said, and written about, than practically achieved.

At the outset, it must be clarified that becoming an integrated force does not mean that the independent Services become subsumed into one entity. In fact, the requirement to succeed in integration is just the opposite. The unique characteristics of the three domain-centric forces—land, maritime and air—have to be well-honed and maintained at a high level of competence before any attempt at integration is to be made. Only after achieving this milestone can an individual Service start to contribute meaningfully to an integrated force. On the face of it, this assertion might seem paradoxical, but even a quick analysis will bring out the fact that the understanding and application of the unique capabilities of domain-centric forces, suitably adapted, is the cornerstone of an integrated force.

In order to achieve the necessary competence to adapt the core characteristics of a domain-centric force, a soldier, sailor and/or airman needs to be a professional master of his or her individual domain. In other words, only after achieving professional mastery of the single Service domain can an individual aspire to transcend into a different and higher level of competence necessary to deal with the complex requirements of an integrated force.

Professional mastery is a concept that has been, and continues to be, discussed and debated by almost all military forces. At the basic level, professional mastery is the ability of an individual to perform an assigned task optimally and to the highest level of competence. The requirement to have adequate professional mastery varies with the different levels at which individuals work and can be considered a progressive upwardly inclined graph. Since a number of inputs—such as training, education, experience—goes into the creation of professional mastery it is difficult to quantify and measure it. However, the complexity of creating an integrated force far outweighs the challenges of single-Service professional mastery.

Only personnel who have achieved domain-centric professional mastery, either an individual or a collective group, have reached a level of competence when they understand the nuances in the development, application and sustainment of the power generated by

the systems that operate in their domain. Further, professional mastery permits them to visualise and apply their domain-centric competence to creating integrated effects in an optimum manner. At the higher levels of command and direction from government, professional mastery also indicates the position and stature of the integrated force vis-à-vis other elements of national power and the national security calculus. The holistic application of force—lethal or otherwise—by an integrated military force is completely underpinned by domain-centric professional mastery resident in independent Services.

In the 21st century, a single domain-centric military force is a complex system of systems, demanding in-depth conceptual understanding and technological know-how of the systems by all personnel. While the minimum required professional mastery could be laid down, single Service mastery is dependent on the proficiency of the entire force. Only a force that has achieved collective, single domain-centric professional mastery will be able to seamlessly dovetail with the other Services to create the desired integrated effects to ensure national security. National security, from a military perspective flows from the foundation of single domain-centric professional mastery.

Air Power and Irregular Wars: A Retrospective Look (#319)

Key Points

- *In the 1990s air power emerged as the supported rather than the supporting element in the application of military force in the pursuit of national objectives.*
- *When appropriately employed, stand-off air power capabilities are able to dominate both air-land and air-sea engagements.*
- *Air power is highly prone to being directly influenced by the context of its application.*

In many ways, air power is viewed as one of the fundamental, and at times critical, elements of Western military power. Its presence is tangibly visible even when not being employed to apply lethal force and its technology-enabled capabilities seem untouchable in its sophistication. Air power is also seen as a strategic advantage of the mature military forces and therefore an irregular adversary always attempts to neutralise this source of capability advantage. This quest has led to the adoption of asymmetric means by irregular forces globally. It is ironic that perhaps the best illustration of the employment of asymmetric means was through a novel employment of air power against arguably the world leader in air power, when the World Trade Center twin towers were destroyed in September 2001.

It was in the 1990s that air power emerged as the supported rather than the supporting element in the application of military force in the pursuit of national objectives. However, this perceived predominance was short-lived since the war on terror in the 2000s reduced the relative importance and significance of air power, at least outwardly. With the advent of the US-led Global War on Terror (a term that has since fallen into disuse) the prevalent belief was that the global security environment had been transformed. Further, it was felt that this

transformation made air power, which had by now been fine-tuned into a precision instrument, less effective against emerging threats.

In the discussions to delineate the role of the military forces in irregular wars, what has not been appreciated fully is that air power is the only element that can establish the necessary superiority to achieve command of the air to ensure that surface forces could operate freely and without interference anywhere in the world. Stand-off air power capabilities are able to dominate both air-land and air-sea engagements. However, there are two caveats to this sweeping statement that puts it in context. The first caveat emanates from the trend in surface combat to move into complex terrain where tactically dispersed irregular forces prefer to operate because they become elusive targets. When man-portable air defence systems are added to the mix and the lower altitudes become contested air space, the assurance of absolute control of the air will not be universal.

The second caveat stems from the prevailing focus on limiting own casualties, especially during the application of lethal force from the air. This casualty-aversion tends to dilute the effectiveness of air power, which in turn becomes a limiting factor. The limitation is particularly noticeable when air power is functioning as the principle support for ground forces in that are contact with, and pursuing an ephemeral adversary. In these circumstances, the strategic value of obtaining absolute control of the air is also diminished, even when countering irregular forces with absolutely no air power capabilities. Irregular wars act as a limiting factor in the effectiveness of air power—from benign to the lethal application of force.

In the European theatre of operations in the 1990s the application of air power in the pursuit of national and coalition objectives was a resounding success. Air power was applied in its most sophisticated technical form and achieved spectacular tactical results that contributed directly to strategic victory. However, in the 2000s, air power applied against irregular adversaries in almost perfect technical-tactical co-ordination at its precise and proportional best, did not deliver the sought after strategic victory even after two decades. Why did air power not

deliver a strategically decisive end-state despite having achieved near-perfection in creating the desired effects?

There are many contributory factors, at all levels of war, to this diminishing return from high-end air power in irregular conflicts. Even so, the primary reason is the very perfection that has been achieved by air power in the technical-tactical sphere. The near perfection of the application of air power has motivated and forced the irregular adversary to find ways to neutralise the tremendous advantage that air power provides to conventional military forces. Air supremacy invites recourse to asymmetry—that is what happened in the early 2000s, a classic case of the superiority edge being whittled away until it becomes non-existent.

Another factor that contributes to the dilution of air power application, and one that is normally not discussed by air power enthusiasts, is that however important air power may be to winning the battle, campaign or war in an irregular conflict, it is only one part of the broader struggle for creating lasting influence among the people. Perhaps only a catastrophic nuclear war can create a truly conclusive end-state through the application of air power. Hopefully this will remain an unlikely event.

Ever since the attacks on the World Trade Center in 2001, the strategic narrative regarding air power and its application has been marred by the tactical errors that have been committed. There are numerous examples of missions that should not have been undertaken and therefore have led to highly publicised failures. Analysis shows that the fault lies not in the application of air power but in the misconstrued theories that underpin its application, which are developed without sufficient appreciation of the contextual nature of conflicts and wars. A theory that suits a conventional war will not lend itself to being adapted to irregular wars.

Air power, of all the elements of military and/or national power, is most prone to being directly influenced by the context of its application. The context therefore becomes a critical factor in the success or failure of air power. As an element of national power, air power's technical-

tactical excellence and its ability to apply precise, proportionate and discriminatory force has reached unparalleled levels in the annals of war and conflict, in the past decade. Similarly, the inherent spread of its capabilities and the broad spectrum of its employment—from delivering humanitarian aid to the lethal application of force—have no equivalent to compare. However, air power is not the panacea to all the mistakes in the application of force, which tend to detract from the ultimate aim of winning the battle, campaign and ultimately the war.

A retrospective look at the employment of air power in irregular wars indicate that the need is for a broader spread in its application that leverages its inherent flexibility couched in its precision and proportionality. Employed contextually, air power can create the exact effect necessary to turn the tide of an irregular conflict; even one that seems to be heading towards a complex and protracted situation.

Air Power and Effects-Based Operations: The Need for Deeper Analysis (#320)

Key Points

- *Over the past few decades, the development of air power concepts of operations has been based on the need to create the necessary effects to support the joint EBO.*
- *The core concept of EBO is that devastating fire power, delivered with precision on pre-selected targets of strategic importance will create the desired effect.*
- *The strategic development of air power suffers from the disadvantage of a lack of inclination to carryout detailed analysis of its own future progression.*

Effects-Based Operations (EBO) is a term and a concept that is difficult to define precisely, with a large number of definitions available in the literature on the subject. Perhaps the one that comes closest to being definitive is the one provided by the US Joint Forces Command that states, '[EBO is] a process for obtaining a desired strategic outcome or effect on the enemy through the synergistic and cumulative application of the full range of military and non-military capabilities at all levels of conflict.'

Over the past three decades or so, the development of air power concepts of operations has been almost fully based on the need to create the necessary effects that would support the joint EBO. Success in this endeavour has been somewhat diffused, less than optimum and not always assured. This situation indicates that a more in-depth analysis of the factors that influence the application of air power must be undertaken to ensure the correct trajectory for the development of concepts of operations.

The strategic development of air power has long suffered from the disadvantage of a lack of inclination and motivation to carry out detailed analysis of its own progression and evolutionary needs. Sufficient intellectual capital has not been

invested in understanding and then creating the path for air power to evolve as an effective envelope force capable of creating the necessary effects to achieve the desired political end-state. For the first century of its existence as a military force element, air power has laboured within this restricted environment, where intellectual capacity for future development has always been constrained. The main reason for this malaise perhaps lies in the nature of air power that attracts people with a proclivity for action more than for intellectual investigation that leads to sustained development of theories and concepts.

The contemporary trend to box air power, its concepts and application into a contextual war against irregular forces, when viewed against the broad spectrum of conflict scenario, is incorrect. In order to realise its full potential and from a developmental point of view, air power must be conceptualised in the context of conventional wars. This is so because success in conventional wars requires the employment of the full spectrum of air power capabilities, before during and after the conflict. In turn, only the availability of full-spectrum capabilities would permit the contextual tailoring of air power application necessary to cater for emerging circumstances.

Air power thinking and concept development must remain broad-based in order to retain the flexibility necessary to overcome operational and tactical challenges and peculiar battlefield issues. Overcoming operational and tactical challenges is critical to the success of air power application but they only form a small although crucial input into the capability development process. The major influence will have to be a broad assessment of national security needs to ensure an extended horizon for capability development.

Air Power developmental thinking in the early days was dominated by the 'strategic school' of thought that tried to position air power as the element that would win wars rapidly and at lesser cost in treasure and lives. This concept was a direct result of the traumatic carnage experienced in the trenches of World War I. In a somewhat lackadaisical manner, the use of the atom bomb at the end of World War II was viewed as validating the concept of strategic bombing to

'win wars'. Thereafter, a series of concepts—such as the air-land battle that were developed—reinforced the conventional view of air power as being predominantly a support element for surface operations. This, somewhat unforeseen development, clearly demonstrated the less than optimum understanding and lack of analysis of air power capabilities and their technology-enabled exponential growth. The same lack of incisive analysis was visible when air power absorbed Colonel John Warden's appreciation of the enemy as a system of systems and adopted EBO as the prevalent concept for the application of air power.

Why has it become increasingly important to analyse new concepts before employing them? Air power today is an instrument of national power that can be applied with precision, proportionality and discrimination to create the desired effect across a broad spectrum of activities—from delivering humanitarian aid to fighting a war of national survival. This spread and depth of air power capabilities make it imperative to analyse the applicability of concepts before they are employed. The reason could be that air forces as institutions did not possess the intellectual depth required to cultivate a culture based on inquisitive analysis at the conceptual level. Problem solving efforts were focused on tactical challenges—as action-oriented people almost always do. Pragmatic questioning of the veracity of a concept that had been proven once in employment was a bridge too far. EBO remains in this basket.

The celebrated success of air power in Operation *Desert Storm* returned the strategic school to centre stage, making air power enthusiasts reiterate the claim of air power being an independent war-winning force. This claim was further reinforced by the demonstration of air power's success in the limited engagements in Europe in the 1990s, mostly against non-air power possessing adversaries. No doubt, these air campaigns were brilliant in their execution and achieved conclusive results. However, on the other hand they negated a climate that was conducive to developing an analytical culture within the air power community. They did not anticipate the on-coming irregular

wars in which air power would get embroiled, starting with Afghanistan in 2001 and continuing to the present day.

The core concept of EBO is that devastating fire power, delivered with precision on pre-selected targets of strategic importance will create the desired effect. The associated calculations, like its effect on the general population and on post-conflict stabilisation, are glossed over in the selection of priority targets, which were mainly aimed at changing the behaviour pattern of an adversary. The fundamental requirement to influence the belief system, the basis of winning an irregular conflict, does not feature in the operational level EBO concept. EBO, whenever it has been applied, has so far achieved effects that only alter the behaviour pattern, especially of the adversary leadership, which is at best transitory. Strategic paralysis, achieved through the application of overwhelming force, has no place in irregular wars.

A basic blemish in the development of air power theories has been the flawed perception that a proven concept has universal validity. This is the first step towards becoming dogmatic and reality disproves this premise. The prevalent analytical stasis creates a loss of flexibility in air power employment and is the first step towards assured failure. The current impasse, where air power is falling short of expectations in the on-going irregular wars is a case in point. Air power theorists need to act now in order to rejuvenate the analytical approach to air power concept development and application if the current situation is to be avoided in the future.

Multi-Domain Integration (#322)

Key Points

- *The effectiveness of a military force is dependent on its technological advancement and its ability to innovate.*
- *Multi-domain integration creates flexibility to rapidly redesign a force fit for purpose.*
- *In order to achieve true multi-dimensional integration, the Services must manage their domains through a process of automatic and continuous interaction with each other that transcends the physical distinctions of the domains.*

The development of a more sophisticated model for the employment of a military force clearly indicates two fresh realities. First, it has been accepted that there has been an erosion of the holistic power projection capabilities of the force in the contemporary operating environment. Second, it is also true that in order to be successful, modern military forces must retain the in-built ability to continuously adapt and respond faster than potential adversaries to emerging challenges. A military force must be able to fight and win today's campaigns while developing the capabilities and a coherent model for their employment necessary to win future conflicts. This is strategic agility. Essentially strategic agility is the ability to synchronise these two time-divided horizons in order to create a force that can truly become an element of national power.

Even though military forces have been traditionally structured in the three physical domains—land, maritime and air—technological advances have brought in space as yet another physical domain and cyber and the electro-magnetic spectrum as two non-physical domains. The human domain, which can be further divided into the physical and the cognitive, add a further dimension to the complexity faced by military forces. The effectiveness of a military force is dependent on its technological

advancement and the capability to operationalise innovative concepts and ideas. Multi-domain integration is one such idea.

Before attempting to define multi-domain integration, it is necessary to place this idea itself in its right place. It is an idea that creates a model for the employment of military forces rather than generating a blueprint for a force design initiative. In turn, the joint employment of a military force is a direct function of single-domain professional mastery resident in individual Services. Historically, the initial move towards creating joint forces and subsequently to achieving seamless jointness between the three Services could be seen as precursors to multi-domain integration. Therefore, the idea by itself is a progression of the past. The difference is in the nuanced manner in which the idea is conceived to spread across all levels of war, and like all evolving ideas it is difficult to define in precise terms.

Multi-domain integration can be defined as an idea that creates the ability to integrate the individual and collective capabilities resident in each domain-centric Service into a flexible and reconfigurable whole in such a way as to ensure that the end-capability is greater than the sum of the individual parts in the mix; with the guarantee that the force design is tailorable to context. The focus here is on the ability to create a flexible design necessary to reconfigure the force. In contrast to a joint force, multi-domain integration creates the flexibility necessary to rapidly reconfigure the existing force to design a force fit-for purpose in a contextual manner.

Military forces that are relatively small numerically, like the Australian Defence Force, also face security challenges that are broadening, making it imperative for the military forces to find more innovative ways to fight and win wars of necessity. Even in military forces that are relatively small, the effective adoption of technological force multipliers will be able to lift them to the realm of being a middle-power force. These military forces have to maintain an 'edge' over potential adversaries in order to be an effective deterrent, and when required, to be a credible coercive force. As technology becomes readily available to most military forces, the numerically challenged forces

have to be continually innovative in order to maintain the 'edge'—in terms of technology, concept development, training, education, and agility both tactical and strategic—that is vital to its success. The idea of multi-domain integration fits into this sphere of activity by providing an overarching strategic umbrella for the development of concepts at the strategic, operational and tactical levels.

At the conceptual level the idea of multi-domain integration is the one that creates a model that can be adapted to suit the requirements of a particular military force. The critical characteristic of this model is flexibility. Sufficient in-built flexibility within the model also caters directly to the need for the military force to be strategically agile. This model has to be developed at the highest strategic level of the force. When the idea of multi-domain integration is superimposed on the three levels of war—strategic, operational and tactical—through the model that has been created, the relationship between the idea and the realities of war become clear.

The starting point for multi-domain integration to take place if for the force to have a clear understanding of joint operations and the ability to conduct them effectively. If this has not yet been achieved within a force it will find it difficult to embrace the idea of multi-domain integration. Multi-domain integration could be seen as the final step towards achieving seamlessness in the military forces. So what is seamlessness in a military force? It is necessary to understand this concept in order to come to grips with the higher level concept of multi-domain integration. Although joint operations are conceived and commanded at the strategic level, its execution is focused at the operational level, as the name implies. Seamlessness in a military context does not mean that the force is devoid of seams that exist between domain-centric forces, it only means that an external observer or adversary will not be able to distinguish or see the seams that exist.

Only after a military force becomes seamless, not only by its own reckoning but also in the eyes of the adversary, can it start the process of multi-domain integration. In order to integrate, a domain-centric Service, must be designed to fit perfectly with the others, it must also establish

common protocols regarding the exchange of information across the domains and, perhaps most importantly, know its place within the whole entity. The Services must start to manage their domains through a process of automatic and continuous interaction with each other that transcends the physical distinctions of their individual domains. The successful creation of such a military force is difficult because of the large number of variables involved, especially in the two non-physical domains.

Creating and maintaining a military force that has achieved true multi-domain integration will require almost continuous integration of combat capabilities of the domain-centric Services in a contextual manner. The fundamental requirements for a military force to create a model that is designed to achieve multi-domain integration can be listed as: being able to function seamlessly as a joint force at the tactical and operational levels; having the ability to create a strategic force-structure grid that is designed-for-purpose; the ability to devolve as well as accept operational and tactical innovation from and into the strategic grid; adequacy of the resilience inherent in domain-centric Services, arrived at through professional mastery of the domain; and the ability of the networks to withstand external and perhaps, more importantly, internal buffeting. Multi-domain integration is a vision of a bright future, although transforming this vision into reality will involve a long and arduous journey. The success of multi-domain integration will depend on whether or not the vision can be transformed to reality, an arduous task since the idea goes beyond being a mere vision for the future. Achieving such an integration is the only way a military force can prepare itself to meet the challenges that have yet to be foreseen in what remains of this century.

The Evolving Command and Control of Air Bases (#323)

Key Points

- *Air base C2 has not evolved in parallel with the C2 doctrine of other air power capabilities.*
- *Air bases, as a critical enabler of power, will be employed under the fundamental air power tenet of centralised control, decentralised execution.*
- *The application of the 5th Generation Air Force will become constrained if the C2 systems for bases is not matured in parallel with that of other air power systems.*

Command and Control (C2) is fundamental to the effective and efficient application of air power. The concept of C2 in the context of Australian application of air power has constantly evolved since the establishment of the Royal Australian Air Force (RAAF) in 1921, and prior to this as part of the Australian Flying Corps. Indeed the establishment of the RAAF, as a distinct and independent fighting force was an acknowledgement of the highly technical and specialised nature of air operations. The creation of an independent air force was also an acceptance of the importance of ensuring personnel who fully comprehend the complexities of aviation and the application of air power are appointed to command and control air power capabilities, normally vested in the Air Force.

The evolution of RAAF C2 has been shaped by the lessons learned across multiple theatres of operation and heavily influenced by major coalition partners. In the past decade this evolution has seen the Air Force's operational C2 largely modelled on the C2 tenets of the United States Air Force doctrine, suitably adapted to RAAF conditions. It acknowledges that Air Force capabilities tasked to support mainstream operations also require a degree of specialised control and oversight. This is particularly evident in the establishment of an air and space operations centre within Joint Operations Command and the use of the tactical air control system as the principle mechanism through which the tenet of

centralised control and decentralised execution is applied to the conduct of air operations.

Under this model, Director General Air (DGAIR) or Director General Air Command Operations (DGACOPS) is responsible to Commander Joint Operations and Air Commander Australia for the operational planning and execution of air power contribution to operations and exercises. The RAAF Force Element Groups and Wings remain responsible for the capability management and force generation of their units against preparedness requirements. Until recently this model has been largely airborne platform-centric, based on the air tasking cycle and the air task order to generate air missions. A notable omission under the centralised control model for the employment of air power has been air base capabilities generated by the Combat Support Group. This support is often taken for granted and the means through which the capability is developed, planned, tasked and controlled have been ill-defined.

Historically, operational command and control of air bases have been ambiguous and inconsistent across the Air Force and/or Joint domains. Whilst air base support to operations has been a constant, there has been a paucity of doctrine on air base command and control. The doctrine that does exist primarily focusses on tactical C2 rather than operational C2 of air bases and their employment during the conduct of air campaigns and in support of Joint and Combined operations. This lack of doctrine has seen air bases assigned under varying degrees of operational authority of senior Australian Defence Force commanders including being directly controlled by the Joint Task Force Commanders, Land Component Commanders, and/or remaining under parent unit chain of command.

In the military context, air bases are a complex system of systems. They are the geographical locations from which the Air Force flies, fights and commands air operations and are a key aspect of Air Force's ability to project and sustain air power during both peace and war. Air bases are operated by a highly specialised and, at times resource constrained, workforce which is often required to support multiple lines of operation from permanent and expeditionary locations. The Air Force's ability to provide the Government with effective air power is dependent on the

capability of the force to optimally operate as a system of systems that combine its airborne platforms, air power support systems and air bases. While the RAAF generates platforms from individual functionally oriented Force Element Groups, the operational employment of the force needs to be harmonised to optimise air power effects across the full spectrum of operations.

The diluted centralised control of air bases has been acknowledged as part of Plan JERICHO. There is now direction for the modernisation of air base C2 and the implementation of enhanced C2 applications and decision support tools for the Combat Support Group. Work has also commenced to achieve these objectives and improve the operational command and control of air bases. Most notably, Air Commander Australia has directed the establishment of a permanent and dedicated Combat Support Division (CSD) as part of the air and space operations centre under Operational Control to DGAIR / DGACOPS for the centralised control of RAAF combat support and air base functions. This provides the air and space operations centre with a dedicated Director Combat Support Division to support the centralised control of air bases and specialist combat support planning staff.

Additionally, the future Air Base C2 Capability Systems seeks to fuse digital data feeds from permanent and expeditionary air bases into a centralised Air Base Command Network, which in turn will be interoperable with the tactical air control system to better support operational control of air bases. This approach allows a cross-theatre perspective to be maintained, rather than continuing as a penny-packeted force meeting purely local objectives. This limited combat support force can be prioritised to achieve a multitude of tasks and employed appropriately to meet prioritised objectives. The prioritisation is particularly important for future agile basing concepts where combat support elements will require a higher degree of flexibility as their combat support activities become less static. Importantly, this centralised control does not forgo the requirement for air bases to be responsive to tactical formations that they are required to support to achieve their directed mission. However, control of air bases will generally be retained by DGAIR / DGACOPS.

Critically, as the Air Force continues to progress towards becoming a 5th Generation Air Force, air bases also are included as part of this evolution. The air bases must develop into 5th Generation Air bases that support the operation of 5th Generation air platforms. (Pathfinder 309, *5th Generation Fighting Airbases*, May 2018). This includes empowering air bases with appropriate modern digital combat information systems which fuse and interoperate with the tactical air control system that provides DGAIR / DGACOPS and Director Combat Support Division improved situational awareness and decision-making support. Once it is matured, the system will result is a much more responsive and effective, centrally-controlled system of air bases.

The Importance of Control of the Air in Contemporary Conflict (#324)

Key Points

- *The need to fight for, obtain and then maintain control of the air was understood from the very beginning of aerial warfare.*
- *Control of the air is defined as 'the ability to conduct operations in the air, land and maritime domains without effective interference from adversary air power and air defence capabilities.'*
- *Developments in air power have made it possible for irregular forces to contest control of the air through the concept of denial of the use of airspace*

The first dedicated role that air power undertook as a military power projection capability was that of observation, which has over the years developed into the sophisticated capacity to carry out intelligence, surveillance and reconnaissance (ISR). However, simultaneous to the development of the observation role, it was recognised that control of the air was a prerequisite for its success, since the safety of the Observer platform could only be ensured by controlling the air around it. From the very beginning of aerial warfare, the need to fight for, obtain and then maintain control of the air was understood by both tacticians and strategists.

From the need to protect a crucial asset in the air to ensuring that own surface forces were not subject to attacks from the air was a small step during the initial phases of World War I. By the time World War I came to an end there was an implicit understanding within the military aviation community that the fundamental role of air power, its raison d'etre, would be to establish control of the air over the battlespace. In the inter-war years that followed, the battlespace by itself started to be defined in different ways and the concept of control of the air also started to become a more sophisticated idea. This was bound to happen

with the technology-enhanced improvements taking place in the application of air power.

So what is control of the air? The Air Power Manual defines control of the air as 'the ability to conduct operations in the air, land and maritime domains without effective interference from adversary air power and air defence capabilities'. Control of the air provides a military force with the freedom to attack, freedom from attack and freedom to manoeuvre, achieved through the disruption, degradation and/or destruction of the adversary's air power and air defence capabilities. Control of the air, therefore, is an essential criterion for the success of all military operations. This fundamental premise has been a tenet of military planning since World War II.

The nature of war—the quest to achieve political objectives through the application of force—has not changed over the years. However, in the past few decades the characteristics and conduct of war have altered significantly. Nations do not legally declare war anymore even when their military forces are engaged in brutal combat. More importantly, contemporary wars are in no manner similar to the wars that were fought up to the 1990s. Today, wars are better termed conflicts and are normally fought between the military forces of a nation-state and some amorphous non-state entity who pursue objectives that are intangible and adopt warfighting methods that pay no heed to the universally accepted laws of armed conflict. This new kind of conflict has been clubbed under the generic term 'irregular war'.

The normal adversary in an irregular war, which typifies contemporary conflict, does not always possess significant air power capabilities. On the other hand, the regular military forces of the nation-state tend to use their air power capabilities as the first-choice weapon, emphasising air power's ability to apply force with discrimination, proportionality and precision. Air power's rapid reaction capability also becomes an asset in combating irregular forces. Under these circumstances, control of the air is not contested and the air assets of the nation-state are free to roam in a benign environment without

having to fight to obtain the necessary control of the air. This has been the case nearly for the past three decades.

This situation has led to the need to obtain and maintain definitive control of the air to being questioned in the planning and execution of normal military operations. The inference from the current state of affairs in the battlespace is that the assets that have been specialised for achieving control of the air are better utilised elsewhere. There are also viewpoints, often vociferously expressed, that air forces themselves could be abolished, based on the premise that control of the air is a given and therefore air power only needs to 'support' the surface battle through strikes when required.

This view is completely incorrect. It is indeed true that the current set of adversaries do not have significant air power capabilities that could contest control of the air. However, developments in air power have made it possible for irregular forces to contest control of the air through the concept of denial of the use of airspace in a designated area and for a pre-designated period of time. In an asymmetrical manner this is also control of the air delineated in time and space. It will be necessary for the nation-state's air power to neutralise such defensive bubbles and gain control of the air. This is only one aspect of irregular warfare.

The proliferation of missile technology and its ready availability to the non-state actors have created another challenge. Surface-to-surface missiles create a situation where friendly forces come under fire and could be denied freedom to manoeuvre. Again, control of the air needs to be obtained in these circumstances with the degradation or destruction of the missile-launch facilities. The increasing sophistication of air defence systems that have also become available to irregular forces makes the need to establish control of the air a critical factor. The air losses inflicted by air defence systems to the Soviet air forces in Afghanistan during the erstwhile Soviet Union's ill-fated, decade-long intervention there from 1979 is a classic example of the critical need to obtain control of the air before launching air or surface campaigns.

Control of the air may not be contested by state-of-the-art, technologically sophisticated airborne systems in irregular wars. However, control of the air is an asymmetry that conventional military forces leverage in combating non-state entities. Therefore, the irregular adversary will always attempt to degrade the asymmetric advantage through multifarious activities. The proliferation and easy access to highly sophisticated and effective air defence systems aid the adversary to contest control of the air, in an asymmetric manner. In turn, one asymmetric advantage is being neutralise by another asymmetric capability.

The characteristics and conduct of war have changed; conventional air power ranges through benign airspace in unquestioned control; but control of the air and the need to fight to obtain and maintain it at the required level can only be underplayed at the one's own peril.

No 3 Squadron R.E.8 aircraft during World War I.
(Pathfinder #308)

No 1 SQN Australian Flying Corps Palestine 1918.
(Pathfinder #317)

Airborne Early Warning and Control Wedgetail aircraft at RAAF Base Williamtown..
(Pathfinder #300)

An MQ-9 Reaper over southern Afghanistan, armed with GBU-12 Paveway II laser guided munitions and AGM-114 Hellfire missiles (Photo: US Air Force).
(Pathfinder #315)

F/A-18 Hornet releasing Mk82 high-drag bombs and counter-measures on a training mission..
(Pathfinder #298)

An Air Combat Officer with No. 2 Squadron, manning the Mission Commander station aboard the E-7A Wedgetail Airborne Early Warning and Control (AEW&C) aircraft.
(Pathfinder #306)

A USAF member guides a Truck Aircraft Loading and Unloading vehicle (TALU)
(Pathfinder #299)

Royal Australian Air Force officer controls the airspace during the advanced forward observers course.
(Pathfinder #319)

Technology

Air Force Infrastructure (#292)

Key Points

- *Air Force basing has historically been influenced by technology and strategy*
- *Infrastructure is expensive, but must be maintained and upgraded to remain effective*
- *Becoming a 5th-generation air force will drive our future infrastructure requirements*

Technological developments of aircraft and Australia's strategic circumstances have shaped the disposition of Air Force bases from the opening of Point Cook in 1914 to the current day. Initially, bases were established near the major industrial and population centres of Melbourne and Sydney. During the expansion of the late 1930s, other bases were established on the outskirts of Perth, Brisbane and Townsville. With the outbreak of war in 1939, additional new bases were established in all the major capital cities and numerous flying training bases were built in south eastern Australia to support the Empire Air Training Scheme. Later, as Japan entered the war, the defence of Australia and support to Allied forces in the Pacific campaign became overriding factors, with numerous airfields being built in northern Australia while a chain of advanced operational bases were established in an arc extending from Timor, through the New Guinea region to the New Hebrides.

Following World War II, the British nuclear program and European space program saw the establishment of airfields at Woomera and Maralinga in South Australia. The strategy of forward basing saw RAAF Learmonth and Cocos Island airfields upgraded in the 1960s and fighter squadrons permanently based at Butterworth in Malaysia. Coinciding replacement of the Mirage with the Hornet in the 1980s, changes in strategic posture saw Air Force reduce its forward presence at Butterworth while developing RAAF Tindal and building RAAF

Curtin. The opening of RAAF Scherger in 1998 saw the completion of the umbrella of bases across northern Australia.

Thus in the past, the location and facilities of Air Force bases were determined by a combination of historical and strategic factors. In recent years, the introduction of new technology in aircraft, such as KC-30, C-17, Wedgetail and P-8, has added some new factors affecting the requirements for infrastructure on each Air Force base. These factors include:

- significant data transfer requirements for 5th-generation aircraft before, during and after missions,
- increased range of the aircraft allowing them to operate from bases further from their area of operation,
- larger, heavier aircraft requiring stronger pavements, and
- increased fuel usage by larger aircraft requiring larger fuel storage facilities.

These drivers have played out in the following ways.

- Wedgetail AEW&C and F-35 aircraft will primarily operate from RAAF Williamtown and Tindal.
- P-8 aircraft will have dedicated support facilities at RAAF Edinburgh, Darwin, Townsville and Pearce, as well as Cocos (Keeling) Islands airfield.
- KC-30 aircraft have suitable support facilities at RAAF Amberley, Townsville, Darwin, Edinburgh and Pearce.

Infrastructure Risks

As we have seen, technological and strategic circumstances have a significant influence on the infrastructure needed at a particular time. Since infrastructure has a significant lead time to design and deliver, understanding how technological and strategic advances will impact our infrastructure requirements is very important. Some changes, like the increased range of a particular aircraft, are relatively easy to understand. What is not so easy is predicting the way Air Force will operate the aircraft as it becomes a truly 5th-generation air force.

Infrastructure is expensive and requires ongoing maintenance and periodic upgrades. This introduces another risk—adequate funding must be available to maintain and upgrade infrastructure. Maintaining adequate funding for infrastructure within the Defence program can be a challenge. By comparison, major equipment acquisitions usually have very long lead times and, once approved, the expenditure profile for a project is difficult to adjust. Over the years, Air Force infrastructure funding has been insufficient to maintain the estate. In addition, decisions to delay infrastructure projects have been made to prioritise funding for current operations or the capital acquisition program. The effect of deferring infrastructure projects, including major base redevelopments, does not generally create an immediate impact on operational capability. However, ongoing deferral of infrastructure projects can lead to increased deterioration of the estate, which increases the risk of failure of critical infrastructure at a time when it is needed for operations.

The *Defence White Paper 2016* and the *Integrated Investment Program 2016* allocated significant funds to 'remediate the underinvestment of recent years in those key enablers essential to realising the full potential of the high technology systems entering service.' Infrastructure is one of those key enablers.

Future Drivers

Climate change will increasingly impact on Defence. Climate change modelling has identified RAAF Townsville and Williamtown as two bases which will increasingly be at risk of flooding, particularly in storm surge conditions. Initially, this is likely to cause short-term disruptions to operations but, in the longer term, it may have a significant impact on the cost of operating and maintaining infrastructure at these bases if not addressed.

New capabilities also impact on training areas and their infrastructure. Air Force has employed weapons for aircrew-training purposes since it was formed. With increased focus on joint warfighting, Air Force now needs to practice releasing weapons as part of a joint

force integrated with Army manoeuvre elements, necessitating a joint Air Force/Army range area. Increases in aircraft speed, weapon effects and gun calibres have resulted in expanded safety areas on weapon ranges. For example, the Evans Head range has reverted to a World War II safety template to allow F-18Fs to use their cannon. In recent decades, this range had been used by F-111s solely for dropping bombs. These changes can also affect the infrastructure required on the training areas.

Longer range aircraft and remotely operated systems may reduce the number of personnel based in remote locations and allow them to live and work in more desirable locations, such as Amberley and Williamtown. This can have flow-on effects to other fundamental inputs to capability such as personnel retention.

Infrastructure is essential to any military force, but particularly an air force. The location and capability of this infrastructure has always been the outcome of many conflicting factors—Government policy, strategic necessity, history and technology. All these factors are likely to continue to influence Air Force infrastructure in the future.

The C-27J Battlefield Airlifter (#297)

Key Points

- *Defence declared Initial Operating Capability (IOC) for the C-27J in December 2016.*
- *The C-27J bridges the capability gap between the ADF's rotary wing assets and medium air mobility aircraft.*
- *The C-27J's versatility makes it suited for a range of air mobility tasks, including air logistic support to the joint force, HA/DR, DACC tasking, and aeromedical evacuation.*

In December 2016, Defence declared Initial Operating Capability (IOC) for the C-27J Spartan Battlefield Airlifter. While ostensibly the replacement for the DHC-4 Caribou, the C-27J represents a quantum leap in Air Force capability to deliver tactical air power effects. Unlike the Caribou, the Spartan has the ability to operate in the modern integrated battlespace, carrying larger loads further while mitigating threats through a combination of increased performance, a modern Electronic Warfare Self Protection (EWSP) suite, and battlefield situational awareness equipment. Moreover, its powerful Rolls Royce AE2100 engines and weather/ground mapping radar allow it to operate in all weather and uncontrolled airspace environments, increasing mission assuredness and reach.

The decision to acquire the Spartan marked the culmination of a series of projects whose genesis lay in a 1978 study to identify a potential replacement for the Caribou. The study concluded that no viable alternative existed at the time; a conclusion also drawn by Government in 1986 when direction was given to replace the Caribou no later than 1990. By 1990, the field of primary contenders had grown to three, the CASA C-295M, CASA CN-235-300M and C-27J Spartan. Although the Spartan was deemed to present the best value for money, the aircraft was still under development and unaffordable within the constraints of the approved budget.

An ideal opportunity to re-invigorate efforts to replace the Caribou was presented in 2007, when the US Government decided to procure the C-27J to fulfil its Joint Cargo Aircraft (JCA) requirement. The Australian Government subsequently made the decision in April 2012 to purchase ten C-27J (JCA variant) aircraft from the US Government through a Foreign Military Sale (FMS) purchase. While the US Government subsequently divested itself of the majority of Spartans following a period of budgetary pressures, a small number still remain in service with the United States Coast Guard and US Army Special Operations Command.

The C-27J is the latest iteration of the Fiat Aviazione G.222, and is manufactured by Leonardo Aircraft Division of Italy. The Italian-built aircraft were flown to the United States for additional modifications prior to delivery to the RAAF. Although it bears a passing resemblance to the C-130J Hercules, and shares common avionics architecture and engines, the C-27J stands alone in its ability to bridge the gap between the ADF's rotary wing assets and medium air mobility aircraft. The C-27J's reduced footprint on pavement areas, when compared with the C-130J, allows it to access more landing surfaces across the globe. While its Short Take Off and Landing (STOL) capability cannot match that of rotary wing assets, the C-27J has a vastly increased cargo carrying capacity over a much greater range, which can reach in excess of 2,000 nautical miles.

A key strength of the C-27J is its versatility. While it possesses many of the features of a conventional air mobility asset, including the Brooks and Perkins Cargo Handling System—common with the C-130J—the Spartan has also proven its ability to execute a variety of missions in foreign air force service. The Italian Air Force (ItAF) has been particularly innovative in exploiting the aircraft's capability of disrupting the traditional role of a battlefield airlifter. Through use of modular 'roll-on, roll-off' components, the ItAF has fielded the Spartan in EC-27J Jedi (electronic warfare) and AC-27J Stinger II (gunship) variants. Also under development is an MC-27J variant that is designed to provide discrete ISR and fire support effects to the battlespace.

Notably, all these capabilities are readily removed, quickly converting the aircraft back into a traditional air mobility asset.

This combination of versatility and performance should prompt a rethink in the command and control (C2) arrangements of RAAF aircraft in the 5th generation battlespace. The agility and broad scope of capabilities presented by this aircraft will need to be reflected by an equally responsive C2 framework, within which the aircraft can be quickly and efficiently transitioned between commanders for tasking within the battlespace. In Air Force experience thus far, the C-27J has demonstrated a range of attributes and capabilities that make it uniquely attractive in supporting Army battlespace effects; assigning it to traditional 'hub and spoke' air mobility missions would under-utilise this versatility. Ideally, the C-27J could blend air mobility missions with responsive and direct support to land forces; and possibly combine both into the execution of a single mission.

Although officially designated as a Battlefield Airlifter, the Spartan's versatility extends to peacetime use, particularly in the Humanitarian Assistance/Disaster Relief (HA/DR) and Defence Aid to the Civil Community (DACC) roles. Here again, the C-27J's low aircraft footprint will allow access to austere airstrips close to the point of need reducing or even eliminating the need to 'hub and spoke' and cross-load cargo at larger regional centres as is often necessary with the C-130J and C-17A. The increased capacity for timely direct delivery will greatly increase the ADF's ability to support HA/DR and DACC tasking.

In the aero-medical evacuation role, the C-27J can access emergency airstrips and load up to 21 stretcher patients per lift. Moreover, the Spartan, with its superior reach, could deliver the patients directly to the most appropriate medical facility, reducing the time and trauma involved in transfers at regional airports. The combination of accessibility, lift capacity and reach is far in excess of that offered by rotary wing assets and, with a cargo compartment capable of fitting three full size 463L Pallets and one half ramp pallet, the Spartan represents a significant increase in light tactical transport capability to that offered by the Caribou.

As experience with the C-27J grows in RAAF service, its potential builds. While all RAAF air mobility assets possess multi-role capability, none share the Spartan's ability to combine accessibility, range and versatility; traits that combine to make this an exciting platform with vast potential in ADF service.

The Inter-Continental Ballistic Missile (ICBM): Myths & Might (#302)

Key Points

- *"Ballistic Missiles" are a class of large-calibre, self-propelled, partially guided or unguided projectiles that follow a ballistic trajectory for most of their flight path.*
- *Unlike cruise missiles, ballistic missiles do not rely on aerodynamic forces and once the rocket-booster expires, it uses its momentum under the influence of gravity, on a ballistic trajectory to fall to its target.*
- *Ballistic missiles follow a trajectory that is described as sub-orbital and their ranges are controlled by a transfer of energy and the launch elevation angle.*

On 30 November 2017, North Korea conducted a test of its new 'Hwasong-15' intercontinental ballistic missile from a mobile transporter erector launcher. North Korea reported that the missile reached an altitude of 4475 km, the highest altitude ever observed for a North Korean missile, over a ground range of 950 km. In analysing the significance of the launch, some observers have used a rule-of-thumb referred to as the '½-rule' to calculate the maximum achievable ground range of North Korea's missiles. These calculations have raised concerns that North Korea has finally developed an Inter-Continental Ballistic Missile (ICBM) can reach continental USA and anywhere in Australia. The simple use of 'ICBM' in reporting can generate a heightened level of alarm in the public, primarily because the term conjures up images of world-spanning nuclear reach. But there is more nuance to ballistic missile threat than that portrayed by such a simplistic characterisation.

The term 'ballistic missile' refers to a class of large-calibre, self-propelled, partially guided or unguided projectiles that follow a ballistic trajectory for most of their flight path, under the influence of gravity. Typically, these missiles carry large warheads or other payloads and have a range of hundreds of kilometres to in excess of 10 000 km. Medium & long-range ballistic missiles are generally regarded as strategic weapons due to their reach and

the destructive potential of their warheads. Ballistic missiles are generally categorised by the characteristics that describe the system design or range performance:

- **Ground range.** Designations based on commonly used distances as listed in the table above, in the absence of a universally accepted standard (eg South Korea's 'Hyunmoo-3C **Medium-Range** Ballistic Missile [MRBM]').
- **Payload.** Payload subsystem designations include conventional, nuclear, chemical or biological warhead, and Multiple Independent Re-entry Vehicles (MIRV) in a single payload (eg China's 'DF-5B **MIRV**');
- **Propulsion.** Propulsion subsystem designations based on solid or liquid propellant rocket motors and the single or multiple stage rocket motor design (eg North Korea's 'Hwasong-15 **2-stage, liquid-fueled** ICBM');
- **Launch segment.** Launch system-based designations such as land-based, ship, aircraft, submarine, or mobile transporter erector launcher (eg North Korea's 'KN-11 **Submarine-Launched** Ballistic Missile [SLBM]'); and
- **Target-based** designations (eg China's 'DF-21D **Anti-Ship** Ballistic Missile' or 'carrier killer');

As different laws of physics apply to describe the motions and trajectories for long-range cruise and ballistic missiles, there are different systems requirements for mission planning, propulsion, guidance, control, and payloads. Cruise missiles typically use propulsion and lift-generating wings, with manoeuvrable control surfaces, and use aerodynamic forces to fly a preplanned trajectory, including mid-course changes. The ballistic projectile or payload is typically propelled into motion by a single and limited duration energy transfer event, such as an exploding artillery round or ignited rocket motor. Once the energy transfer event is complete, the projectile will have reached its maximum velocity and its momentum carries it to follow a ballistic trajectory that is mainly shaped by the effects of gravity and, to a lesser degrees, by other influences such as air friction.

Strategic missiles follow a trajectory that is described as sub-orbital. Orbital trajectories are normally associated with Earth-orbiting satellites that are actually in freefall under the effects of gravity and keep missing the Earth in their circular motion. Ballistic missile trajectories are commonly described as following a parabolic arc, however, this parabolic arc is an approximation for a trajectory that is more accurately described

as following a circular motion trajectory about the gravitational centre of the Earth; the physical size of the Earth prevents the ballistic object from completing an orbit before striking the ground, thus defining a sub-orbital trajectory.

The ranges of ballistic missiles are controlled by a transfer of energy and the launch elevation angle, while the direction is controlled by the launch azimuth angle. The missile range is varied by changing the rocket fuel load, similar to artillery crews stacking a different number of explosive charge bags in the gun barrel appropriate to the different attack ranges. Unlike cruise missiles, ballistic missiles do not rely on aerodynamic forces and once the rocket-booster expires, it uses its momentum under the influence of gravity, on a ballistic trajectory, to fall to its target.

The North Korean ICBM missile tests have been reported as achieving ever higher apogee heights with each test launch of a new missile design. The test missiles appear to have been fired at very steep launch angles to achieve a maximum trajectory height, rather than at low angles to test the maximum range. American physicists developed the "½-rule" as a simple rule-of-thumb for non-physicists to avoid the complex maths and estimate the potential maximum horizontal ground range of an ICBM based on knowing the maximum vertical heights observed during test firings, as reported in the media. For example, a vertically launched missile that reaches a height of 400 km could potentially be launched at a lower angle to fly over a maximum ground range of 800 km.

The maths in the ½-rule uses an approximation which is only valid when the observed apogee height can be assumed to be numerically small when compared to the radius of the Earth (6371 km). For a missile observed to reach a 4475 km apogee height, over a horizontal distance of 950 km, the ½-rule would predict a maximum ground range of about 9010 km on a flat Earth. The maths calculation gives a ground range of about 5300 km. The adjacent chart shows a comparison of ground range estimations using maths and the ½-rule, and indicates the ½-rule estimate closely approximates the calculated missile height up to about 750 km. Above 750 km, the ½–rule approximation is not necessarily valid.

Additionally, the maximum range calculation is based on the observed maximum altitude achieved by the test missile. This observed altitude may or may not be useful to determining the maximum

possible range since it is not known if the test missile was fully laden with fuel and a simulated payload weight. A heavier ballistic missile will achieve a shorter range.

This is not to suggest that North Korea's Hwasong-15 could not reach the ranges mentioned by some commentators, but understanding the capabilities of the system requires a complex analysis of a number of factors other than the apogee reached in a test firing. North Korea's missile capability continues to grow as a threat to regional security and stability and the first step in addressing this threat is to understand the nuance of the capability.

Three Stages of the Inter-Continental Ballistic Missile (ICBM) Flight (#305)

This *Pathfinder* is a second in a series on ICBMs (refer #302) and will outline the three distinctly different phases of flight. An understanding of the characteristics of these different phases of flight is important to highlight the different missile operating environments and flight characteristics for guiding the designs for systems that provide operational responses within a ballistic missile defence system.

Key Points

- *Conventional ICBMs typically follow a ballistic trajectory that can be divided into three separate phases based on its mode of operation – boost, mid-course and terminal phases.;*
- *Typically, ICBMs are not designed with adequate kinetic energy to accelerate into a stable Earth orbit and normally follow a sub-orbital trajectory.*
- *The integration of different systems into a single integrated system-of-systems can provide response options to intercept an attacking ICBM during the different phases of its flight.*

Conventional ICBMs typically follow a ballistic trajectory that can be divided into three separate phases as shown in *Figure 1*. The boost phase is the part of a missile's flight when its rockets are thrusting to accelerate the ICBM to the velocity needed to reach its target; the *mid-course phase* is the part of the trajectory that is usually outside the atmosphere where the missile ascends to its apogee height before descending towards its target; and finally, the *terminal phase*, where the missile is coasting, or freefalling through the atmosphere towards its terrestrial target.

The boost phase commences after launch and lasts about 3–5 miutes until the rocket engine(s) expire and is typically completed within the atmosphere. The booster rockets serve to accelerate the ICBM payload onto a ballistic trajectory. They also enable thrust vectoring to control flight and make corrections in order to steer the

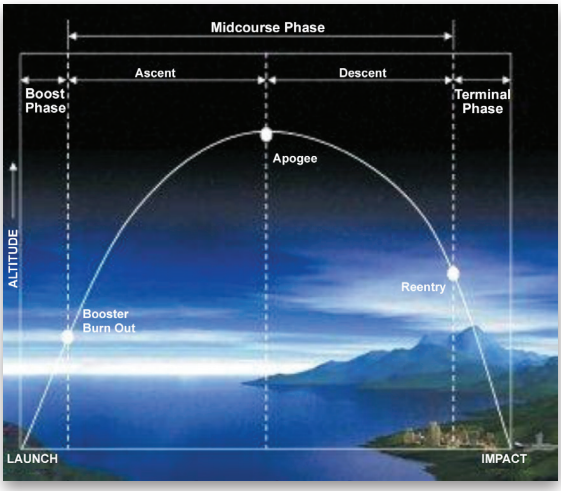

FIgure 1 - Phases of an ICBM trajectory

ICBM onto the planned trajectory towards the target. Depending on the missile, this phase can typically last between three to five minutes.

There may be more than one rocket motor stage in this phase in order to boost the ICBM payload to a higher apogee to ensure that it can ballistically reach a longer ground range. Each spent booster stage is jettisoned after expiring and freefalls back to Earth as uncontrolled debris. The ICBM can reach speeds of more than 24,000 kph before the boosters cease functioning when the propellant expires, and are jettisoned as debris, which will return to earth.

The booster rocket plume displays a significant infrared signature that contrasts against the surrounding atmospheric environment.

The mid-course phase is arbitrarily assigned to the part of the trajectory that commences after the boosters have expired. The booster rockets provide the momentum that makes the missile continue on a ballistic trajectory towards the planned ground impact position. Even though the missile is steered in flight throughout the boost phase, once the rockets are spent, there is no mechanism available to control and direct the movement of the conventional missile. Having been boosted to hypersonic speed to heights above the atmosphere, the aerodynamically

heated ICBM exterior has a hot infrared signature that contrasts prominently against the background of cold space.

After the boosters have expired, the ICBM ascends to its apogee and the point of maximum potential energy, before descending toward Earth. Typically, ICBMs are not designed with adequate kinetic energy to accelerate into a stable Earth orbit and normally follow a sub-orbital trajectory.

The mid-course phase is the longest phase of the missile's trajectory and can last for up to 20 minutes. This phase provides the longest time and predictable opportunities for intercepting an incoming ICBM. Since the missile is neither powered nor in controlled flight during this phase, its predicted trajectory can be used to plan an exo-atmospheric intercept based on orbital dynamics and circular motion.

During the descent whilst still in space, the ICBM's mission payload (e.g. warheads and/or decoys) separate from the ICBM for each to follow their independent ballistic trajectories towards the target position.

The terminal phase commences when the ICBM's mission payload re-enters the Earth's atmosphere and continues until the warhead functions in an air burst or on ground impact, depending on the fuzing mechanism. The conventional payload is typically designed to follow a ballistic freefall trajectory path, in uncontrolled flight. This phase of flight can take about a minute for a typical strategic ICBM warhead, which might be travelling towards the ground at speeds of around 3,200 kph.

These characteristics of the three separate phases of flight of an ICBM are useful to highlight the different signatures and trajectories that could in turn drive the designs for systems to detect, track, and engage, the missile. The defence systems will have to take advantage of the contrast that ICBMs provide against the different backgrounds of being in space or being in the atmosphere, and while transitioning across the two different environments.

Anti-missile defence systems are challenged by the need to provide a quick response to engage the target missile—preferably close to its launch site—and also to consider the flight time to intercept a hypersonic target (See *Figure 2*). The interception of an ICBM in its relatively slow *Boost*

Phase could end its mission, regardless of its range or intended aim-point, providing an operational response that defends nations and global areas. A *Mid-Course Phase* intercept provides an operational response to defend both a wide regional or localised area. A *Terminal Phase* defence intercept provides protection for a localised area or deployed task force.

The integration of different systems into a single integrated system-of-systems can provide response options to intercept an attacking ICBM in the different phases of its flight. Such a system would provide a layered defence capability that provides options to increase the probability of successfully disrupting the ICBM mission at different points in its trajectory. The achievement of a mission-kill does not negate the likely collateral damage through the warhead remnants and debris resulting from a successful intercept.

The operationalisation of hypersonic aerodynamic vehicles with flight controls, boosted from an ICBM and then aerodynamically flying an evasive trajectory to its target, is expected to force a change in the current approach to missile defences.

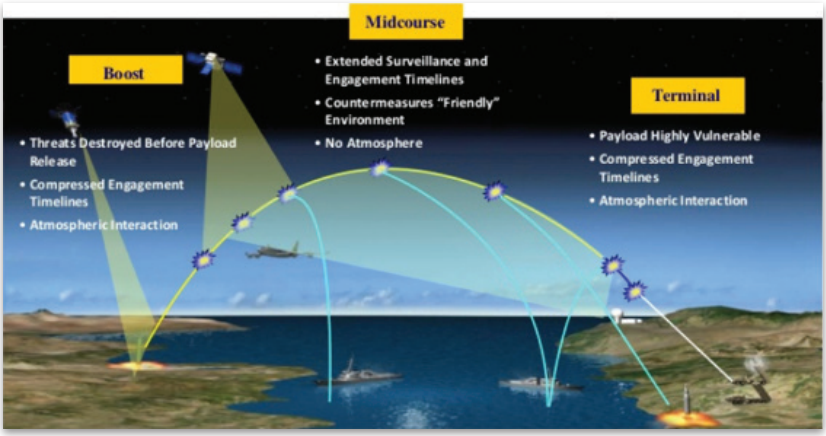

Figure 2 - Challenges faces by anti-missile defence systems during the different ICMB flight phases.

Lessons From the World Game:We Won't Know What We Don't Know Unless We Try (#311)

Key Points

- *Complex systems require comprehensive and exhaustive testing to prove their reliability and efficacy.*
- *The ACC and JIAMDS will require non-traditional testing methodologies to ensure that unanticipated failures will not occur.*
- *Without comprehensive testing, complex systems are likely to fail in unexpected and unanticipated ways.*

Without doubt, the global focus on the 2018 FIFA World Cup clearly establishes football as the world game. This high level of interest has placed demands and challenges on various technology-enabled functions, which bring the games to the world population and requires innovation to solve. The requirement to adopt technological innovations to optimise performance is equally applicable to the ADF as it introduces new capabilities into operational service. So, what can the ADF learn from the 2018 FIFA World Cup regarding the introduction of cutting-edge systems in a cost-effective manner?

What can be learned beyond the usual platitudes from commentators regarding teamwork, national pride and the inevitable debates regarding controversial refereeing decisions? At both the national and international levels, the organisation and conduct of the World Cup is a complex system of systems with multiple stakeholders ranging from national teams, fans, FIFA officials and global media companies. The world's most watched sporting event requires legacy systems (the referee) and new technologies (Video Assistant Referee) to work seamlessly on the pitch when matches are in progress (operations). In addition, the games must be transmitted by multiple media outlets through traditional means and streamed using complex new technologies. Recent unexpected outcomes during the games, such as pitting the

referees against their video assistants, and the well reported problems of streaming the games in Australia indicate that a realistic, comprehensive and exhaustive testing regime is mandatory to understand and anticipate the limitations of a complex system.

The Air Force is in the process of introducing arguably the most complex system of systems ever commissioned by Defence, notably the Air Combat Capability (ACC) and the Joint Integrated Air and Missile Defence System (JIAMDS). These systems, jointly, will enhance the efficiency of the application of air power. Like the 2018 World Cup, the ACC and JIAMDS will need to operate seamlessly if the operators (players) and the military commanders and strategic decision makers (audience) are able to optimise the benefits that accrue from the combination. In order for the ACC and JIAMDS to extract the best from the new systems, both must trust the ability of the system to assist them and have confidence in the veracity of the information being presented by the automated sub-systems.

This will only occur if participants have a thorough understanding of the system and can anticipate how the system will operate in realistic scenarios when under extreme pressure. If the automated decision aids (such as the Video Assistant Referee in the World Cup example) provide inconsistent advice to operators and decision makers there will be a rapid loss of confidence in the entire system. In addition, if the system is prone to unexpected catastrophic failures when under stress (World Cup streaming technology is an apt example) it is likely that the system will be operated at a sub-optimal level in order to mitigate the risk of an unexpected crash. Neither of these scenarios justify the investment being made to provide the Air Force with the best future warfighting technology, pertinent to the next generation.

Middle power militaries like the ADF must, by virtue of economic necessity, make compromises between capability and resource expenditure when acquiring new systems. One compromise could be to buy cheaper, and in most cases, less capable systems; that can be equated to the 1998 World Cup, with no automated referee support and matches distributed by relatively few broadcasters on only radio and television. Australia has consciously decided not to pursue this option. Instead, Australia

has decided to buy technically sophisticated, state-of-the-art ACC and JIAMDS systems with all the benefits and inherent risks associated with the new technologies; something similar to the 2018 World Cup with referee decision aids and multicasting on traditional and new platforms.

The compromise that Australia had to make to induct state-of-the-art systems is in numbers—the resource availability simply could not afford large numbers of either the ACC or JIAMDS. There is another inherent challenge to middle power militaries: they do not have the critical mass to stress the sophisticated systems that have been acquired. However, if problems similar to the ones associated with the 2018 World Cup are to be avoided; if users and beneficiaries (players and audiences) are to understand the new systems and have faith in the results, the ACC and JIAMDS have to be tested to the point of failure. This is the only way that the Air Force will be able to operate new complex systems with confidence and be assured that quality information is being presented to decision makers as well as provide a commensurate return on the premium that the Commonwealth has paid for the best available ACC and JIAMDS.

Developing sufficient critical mass to place the ACC and JIAMDS under stress to the point that users clearly understand the characteristics of the systems and are able to anticipate likely outcomes is not impossible but cannot be achieved by relying on traditional exercises and testing means. Testing individual elements of the ACC and JIAMDS, whilst necessary, will not provide the necessary level of confidence that the system of systems will operate as expected. Emerging technologies, such as Live, Virtual Constructive simulations could help to place the whole system under pressure in such a way that real world exercises may not be able to do. Only a high stress, whole-of-system testing environment will provide the understanding of how to manage the ACC and JIAMDS under pressure, provide confidence in the results, and reduce the risk of unanticipated system failure.

Australia's position is not unique, indeed the majority of nations acquiring similar ACC and JIAMDS systems are deemed to be middle powers and find themselves in a similar situation. This provides opportunities for collaborative testing and problem solving by utilising

diverse approaches, which in turn may increase the understanding of the technologies being inducted. Returning to the World Cup analogy, although a great deal of testing had been carried out on the technologically enhanced systems prior to the 2018 World Cup, there were some reported failures of the video assistant referee system. This highlighted the need for enhanced and fully stressed testing of new technologies before they can be considered fully reliable.

The 2018 FIFA World Cup has embraced new technologies for players and audiences but not without unintended consequences. Unexpected failures of streaming technology and inconsistent results from the Video Assistant Referee are examples of modern complex systems not operating as expected when placed under pressure. The result of these failures is a widely reported loss of confidence in the targeted audience coupled with increasing dissatisfaction in new technologies within players and officials. These technologies were intended to assist decision making and improve the level of accuracy in decision-making in the 2018 World Cup.

Australia's ACC and JIAMDS are also examples of modern complex systems that will require rigorous testing if the Air Force is to avoid similar pitfalls. Noting the limitations that are associated with middle power militaries acquiring and operating state-of-the-art systems, it is highly unlikely that traditional testing methodologies will provide operators the confidence needed to use the systems to their full capacity. Only by taking full advantage of every aspect of the ACC and JIAMDS can the Air Force justify the considerable investment that the Commonwealth has expended to ensure optimisation of decision-making for the next generation of warfighters.

Ground-Based Lasers in Space Operations (#312)

Key Points

- *Changing the orbits of space debris will complicate space object tracking and require the space situational awareness mission to update object tracks more frequently.*
- *Using a ground-based laser to deliver kinetic effects on space debris represents a cross-domain activity that requires planners in multiple domains to be cognisant of collateral damage.*
- *Laser emissions may cause interference or damage to objects passing through the beam in front of the object or in the beam spill-over behind it.*

For many people space remains a largely unexplored and empty final frontier but the current amount of space debris that encircles the Earth reflects that our own space 'backyard' is anything but empty. With the use of space-based systems increasing, there is an urgent need to clean-up the Earth's environs and this Pathfinder explores some of the recent innovations to achieve greater utility of space.

An increasing number of states are recognising that unhindered access to space and the protection and correct functioning of their space-based systems are critical to national security. A state's ability to control and influence activities in space through either terrestrial-based, ground-launched, or orbiting systems provides a significant advantage over an adversary's use of space.

Space traffic needs to be actively managed by the monitoring of uncontrolled space debris to limit the risk to orbiting space systems and to avoid orbital collisions. If debris is stable in preferred orbit location, satellites cannot be deployed into that orbital location which, in turn, adds to the overall congestion. In the past decade, protocols have been adopted to reduce the introduction of new debris into orbit.

A significant step towards mitigating the risks to Australian and allied space capabilities from space debris was made with the development of Australia's space situational awareness (SSA) capabilities. These capabilities include the ability to detect, locate, and track debris as the first step in addressing the problem of space debris. (*Pathfinder 273*, September 2016). The solution lies in developing the ability to remove the debris safely and economically.

Many countries are conducting research to develop innovative terrestrial and space-based solutions to reduce the quantity of orbital debris. One potential solution to this challenge is to employ a ground-based laser to detect and remove small space objects through a process known as 'laser ablation'. Laser ablation involves a skyward laser transmission of microwave energy that is powerful enough to melt and erode parts of the space debris, slowing its forward momentum. The thermal heating, by the laser, also breaks down the chemical bonds within the illuminated material and causes particles to be ejected from the object in the form of gas. The action of the separated gaseous matter being ejected from the object contributes to the deceleration of its momentum. With an adequate number of ablation events, the object could be slowed sufficiently to make it descend to a lower altitude orbit and when the object descends to an orbital height below about 200 km, it will be captured by Earth's gravity and burn up on re-entering the atmosphere. Initial research activities have focused on the laser ablation of very small orbiting debris, which only require the use of low-cost lasers using low levels of laser energy.

However, the use of lasers for space debris removal also presents a number of safety and security challenges.

The use of lasers for small object detection is preferred because the wavelength of the laser is shorter than the radio wavelengths used in radar systems, making it possible to combine the functions of small object detection, tracking and ablation into a single system. Laser ablation works by pointing and focusing a laser on an orbiting object when it is flying overhead; the energy that is focused on the object is at a maximum when it passes directly overhead at the closest point

of approach to the laser ground site. The object has to be tracked in order to keep the laser energy pointed steadily at the moving object for a long enough period to generate enough heat for the illuminated material to breakdown. Maximum efficiency of the laser transmission is achieved when weather and atmospheric conditions are favourable and the orbiting object is not tumbling or reflective. With these conditions the object can be irradiated with adequate energy to cause material to breakdown and be ejected as gaseous matter.

However, uncontrolled domestic and scientific use of skyward-pointing lasers may inadvertently cause 'visual interference' and create a safety hazard for air and space activities. Aircraft and satellites might inadvertently fly through a laser emission. Microwave-energy lasers operate on frequencies that are not visible to the naked eye. Whilst the short time taken for a moving platform to cross a skyward pointing laser might not cause any damage, it could disrupt electro-optical sensors; while laser emissions in the visible spectrum might cause hazardous windscreen glare and/or flash blindness to aircrew.

The US Federal Aviation Administration (FAA) regulations for *Outdoor Laser Operations*, provide a good model for controlling laser operations based on priority being given to considerations of safety of aircrew and aviation operations. If the beam originates from below the FAA's minimum altitudes for controlled flight, the FAA stipulates that the laser operator must exercise due regard and is responsible for managing the hazards introduced into the airspace that are associated with the laser operation.

FAA airspace regulations aim to protect aircrew and systems operating in the navigable airspace up to 60,000 feet. Powerful lasers that, if pointed above the horizon can reach space, are being increasingly used for terrestrial purposes (eg science, communications, range finding). The US Department of Defense policy requires that the operation of all US Defense lasers be 'conducted in a safe and responsible manner to protect space systems, their effectiveness, and humans in space'. The Laser Clearinghouse is a division of the US Joint Space Operations Centre and is tasked to make predictive assessments, de-conflicting hazardous laser

operations, and air and space missions. The deliberate pointing of a laser that can ablate or damage a space object needs to be assessed for the potential damage that spill-over radiation could potentially cause to space missions passing inline behind the target.

The Australian Civil Aviation Safety Authority (CASA) enforces similar regulatory requirements to those of the FAA. CASA centrally regulates the safe operation of lasers and high-intensity lights for the "protection of pilots against accidental laser beam strike" Accordingly, CASA requires laser operators to centrally register their laser activities with CASA.

In addition to this operational challenge, there are a number of strategic considerations that need to be taken into account in developing and fielding laser tracking and ablation systems. Countries with interests in space may view the development and utility of powerful laser systems for space debris removal as a potential threat to their space capabilities. A laser system that is employed for space debris removal should be designed for purpose and operated with transparent intent. Other countries need to have confidence that it is being used appropriately and for the benefit of the global space user community. This is normally achieved by using lasers with an energy level that is adequate to damage small-sized debris objects but which is safe for larger satellites and their on-board mission systems, and by sharing the results of the laser operation to support space object tracking.

As the space debris problem continues to increase, there will likely be more laser ablation systems operating in new locations around the world, increasing the probability of laser emissions spilling over. As air and space power continues to be used to respond to varied situations in different locations around the world, expeditionary units will be forced to share the air space with skyward pointing lasers.

Technology: Creating the Next Step-Change in Air Power (#315)

Key Points

- *The pursuit of control of the air has dominated the development, employment and efficacy of air power*
- *Technology-enabled step-change functions will change the realities regarding the application of air power as perceived today*
- *The UCAV-AI combination capable of autonomous operations will find its niche in air power, sooner rather than later*

In the past few decades the effectiveness of the application of military power has become dependent on the ability of the force to be joint, moving towards integrated, especially in the more technologically advanced military forces of the world. A detailed analysis of this trend would find that even within the joint application of military forces, air power tends to be at the vanguard in the majority of the cases. This trend is unlikely to change because of a number of factors, the most important being the necessity to limit one's own casualties in all operations. Air power with its promise of relatively low casualties, at least to it's own forces, therefore becomes the weapon of first choice in all conflicts other than wars of necessity.

The pursuit of control of the air—because the air environment envelopes all other physical domains—has normally dominated the development, employment and efficacy of air power and it will continue to define future developments. In this context the air environment can be characterised as permissive or benign, contested, or denied. In the past fifty or so years, Western nations with adequate air power have not had to operate in any other but a permissive air environment, never having to really fight to obtain control of the air. While this situation has ushered in a sense of complacency, the future may not be the same. A benign air environment could become contested very rapidly and

emerging threats could lead to a denied air environment. Under these circumstances, successful air operations could become difficult at best.

The possibility of a change from a benign to a contested environment has influenced the development of air power capabilities and created a 'system of systems' concept. In this concept, air power capabilities that may have been resident in individual platforms are combined into one 'system' that may not be a single platform but a group that functions as a single system. Uninhabited Aerial Vehicles (UAVs) on ISR missions, operating in conjunction with 4.5-generation strike aircraft provide an early example of this development. It is envisaged that the system of systems approach will culminate in making air power a seamless web capable of masking its vulnerabilities, and dominating contested, or even denied air spaces successfully.

However, only a step-change function in air power capabilities will bring about changes to the manner in which air power is generated, sustained and employed. Two such functions can be identified—the uninhabited combat aerial vehicle (UCAV) and artificial intelligence (AI). Both UCAVs and AI, when fully incorporated into the concept of air power—meaning incorporated into the development, application and sustainment activities—will change the realities regarding the application of air power as perceived today.

The UCAV, a system that combines ISR and strike capabilities, has matured to a level that it is now routinely used to strike time-sensitive targets, especially in the context of irregular wars. This system combines long-term surveillance and near real-time kinetic response, which could be considered a step-change function that has altered the application of air power.

While the UCAV systems have clearly indicated future possibilities, they continue to function with a 'human-in-the-loop' in its decision-making cycle. The application of lethal force continues to be authorised by human beings for a variety of reasons such as ethics, morality and international law. Therefore, the UCAV system sits at a half-way point between traditional strikes from inhabited platforms and the concept of complete autonomy with regard to the weapon release function.

A number of unresolved issues and challenges continue to inhibit their unrestricted use, even as UCAVs are being employed almost in a routine fashion in the on-going conflicts in the Middle-East and South Asia. The legal status of the UCAV operators vis-à-vis the Laws of Armed Conflict, the cost-benefit analysis of their use, the per unit cost escalation, and survivability in contested air spaces are some of the issues to be resolved. Further, the efficacy of UCAVs will have to be re-evaluated if they are to operate in a contested air environment. However, if these challenges are overcome and a visionary approach to the concept of their employment is adopted, UCAVs will provide a step-change function to the employment of air power.

The concept of autonomy in weapon release, from an air power perspective, is closely related to the employment of AI in warfighting functions. Even as the employment of UCAVs have created a number of challenges to military forces, mainly in terms of legal, moral and ethical considerations, the advent of AI adds a new challenge and complicates older ones. Viewed in an unbiased manner, future concepts of operation and emerging employment opportunities that combine UCAVs and AI into a single system point towards a step change function in the application of air power.

Defining AI in a generic sense is not possible since it is an absolutely nuanced entity and means different things in different circumstances. In a military context, AI could be explained as the 'intelligence' introduced into a 'robot'—the term robot denoting any machine capable of perambulation and conducting its own activities regardless of the domain—to ensure that it functions in an autonomous manner with no human input for the full span of an independent mission. From a purely scientific feasibility point of view, autonomous operation is already a reality.

The operational employment of a UCAV-AI combination for the application of lethal force brings out discernible conceptual and mental challenges. Irrespective of the challenges to the employment of AI, its introduction into the decision-making cycle is considered possible in the not too distant future. However, there is still a general lack of trust

in AI, due to such factors as: the fear of a 'wrong' decision being made with disastrous consequences; the inherent human tendency to resist change; and the apprehension of not being in control, compounded by the inherent human need to maintain superiority over machines, individually and in combination. All of these issues inhibit the unrestricted use of AI.

Stemming from the purely cognitive human element of trust, there is also a clearly visible reluctance at the strategic decision-making level to give complete freedom of operation to fully automated combat vehicles. For some inexplicable reason, this reluctance is reinforced when the combination is part of air power, perhaps stemming from the fear of collateral damage from a UCAV-AI combination. Considering the challenges, mostly originating in human reluctance to trust AI, it would seem that the fully autonomous application of lethal air power is still a faraway dream. However, the technical capability exists to achieve this step-change function.

It is difficult to predict the timeframe within which the UCAV-AI combination will find its niche in air power. With its maturation, air power will transcend another invisible step in being the power projection capability of choice. There is no doubt that an AI capable of making weapon release decisions without a human-in-the-loop will be fielded at the operational and tactical levels of war sooner rather than later. Even though the acceptance of such a situation will be incremental, it is bound to start in the not too distant future.

Force Sustainment: The Guided Precision Air Drop System (#321)

Key Points

- *Force sustainment has always been a critical element in the overall success of the employment of military forces.*
- *Irregular Wars require that military forces adapt rapidly to the merging risks and challenges, and the fast-changing circumstances that commonly prevail.*
- *As the GPADS capability reaches complete maturity, it will provide immense flexibility to the combat sustaining force.*

Force sustainment has always been a critical element in the overall success of the employment of military forces. It focuses on ensuring that the force that is employed has the necessary personnel and materiel to conduct and sustain operations both domestically and in expeditionary operations. In the past three decades or so, the trend in warfare has been such that Western military forces have been engaged in irregular wars (IW) fought in faraway places that could at times be inaccessible because of geography or for political reasons.

The focus on expeditionary IW operations indicate two requirements. First is that the military forces need to be able to extend their reach and be able to access terrain that could be rugged and arduous. The second requirement is more important since it indicates the kind of forces that would be needed to function in these changed circumstances. Unconventional forces, normally Special Forces trained to operate in a particular physical domain, tend to adapt much better to the merging risks and challenges, and the fast-changing circumstances that often prevail in IW. By virtue of their training, Special Forces are also more conducive to the insertion, sustainment and extraction requirements of functioning in an IW environment. The deployment and sustainment of such groups is normally beyond the reach of traditional supply chains, which are developed more for

the employment of conventional forces engaged in regular combat operations.

In IW, such Special Force deployments optimise mission effectiveness and have a high level of success in achieving the desired operational objectives. There is no doubt that these missions are hazardous and are undertaken only because they fulfil crucial requirements that contribute directly to the success of a campaign. However, sustainment of these deployments for the preferred period of time is altogether another story. Sustainment creates challenges that take concerted and joint efforts to ameliorate. Assured ability to deliver ammunition, water, rations and war-fighting materiel is a critical element in the planning and execution of these dangerous and vital missions. In order to reduce the risks associated with expeditionary remote area operations by small contingents of Special Forces, it is necessary to decrease the reliance on forward operating bases to mount and sustain these forces. While insertion of Special Forces have evolved over the years, sustainment has not received the same amount of analysis and development.

Since Special Forces normally operate in the IW environment behind enemy lines in hostile territory and without a direct line of support from their home base, the most often used method to sustain them in operations is to air deliver the materiel required. Parachute insertion of the forces themselves and their resupply thereafter is not a new concept and has been practised since World War II. Operation *Market-Garden* is a famous example of parachute insertion of forces, even though the particular operation was not an overwhelming success. The current focus on IW and the associated mission requirements has focused the development of parachute insertion towards precision aerial delivery. A number of next generation capabilities are being investigated, which if successful, will provide unprecedented air delivery capabilities that will effectively support forward deployment of military forces both on land and at sea.

The Special Operations fraternity is at the forefront of developing the tactics, techniques and procedures to facilitate the extended reach of assault Special Forces that usually operate independently and in small,

self-contained groups. A major innovation has been the development of the Guided Precision Airdrop System (GPADS). The ADF Glossary mentions this system as the Joint Precision Air Drop System (JPADS), as explained in *Pathfinder No 75*, September 2007. This system is capable of deploying supplies from high altitudes to inserted Special Forces elements deep into enemy territory and then sustaining them. GPADS can deploy from as much as 25 kilometres away from the designated impact point or drop zone and from up to an altitude of 25,000 feet. The accuracy of insertion is reported to be within 250 meters from the designated delivery point. This stand-off capability diminishes the threat to the supporting air asset from adversary air defences. Therefore, it is ideal for sustaining Special Forces elements that have been clandestinely inserted by employing the free-fall technique. If the sustainment of these forces are done through the GPADS method, the stand-off distances of delivery will minimise the chances of their detection and interception.

The GPADS technology is of strategic importance since it is a force multiplier when employed appropriately within the circumstances of an IW scenario. The system permits the deploying aircraft to remain outside the normal air defence envelope, can be deployed in a clandestine manner, and has the capacity to deliver materiel and supplies to difficult terrain such as mountains and even to populated urban areas— with extreme precision. Another noteworthy technology-enabled evolution has been the development of the light tactical all-terrain vehicle that is 'air droppable'. When used in combination with the demonstrated GPADS capability, it provides unprecedented mobility and greatly increased radius of action to the Special Forces elements operating behind enemy lines on covert, independent missions.

Since GPADS are relatively more expensive, development efforts have started to concentrate on creating single-use solutions, especially since retrieval of precision parachute insertion equipment in war zones is not a practical solution. These single-use systems would be relatively low-cost options. Another development is focused on increasing the GPADS weight carrying capability. Currently, GPADS is restricted to

carrying only 295 kilograms of weight, although systems that have the ability to carry 4500 kilograms have already been demonstrated.

While the focus of developments—in concepts and technology—has been the IW scenario, there is an increasing demand for similar mission capability in the maritime domain as well. There is a concerted push towards adapting the same concepts and technology to increase the reach and reduce reaction times of maritime counter-terrorism and anti-piracy military units. As the capability of the system is being demonstrated and becoming known, the demand for GPADS and a number of similar commercial variants, is gradually increasing. It is expected that as the GPADS capability reaches complete maturity, it will also become easily reconfigurable for use on either land or maritime domains, which in turn will provide immense flexibility to the combat sustaining force. A Modular Autonomous Guidance Unit is also being trialled in an effort to vastly increase the 25 kilometre range of the current system.

The success of Special Force operations is underwritten by the ability of the military forces to sustain them by air. GPADS provides an assured way of delivering the essential equipment to the deployed elements even in remote and difficult terrain. Further, the system assists in increasing the mission endurance of deployed Special Force elements, while ensuring that the covert nature of most of their operations is not compromised.

Future

The Future Air Force (#289)

Key Points

- *A number of recent Defence documents look at various aspects of the future of the Air Force.*
- *The forces and disrupters affecting future air power are largely unpredictable.*
- *Air Force will need to adapt to an unpredictable future*

On 20 April, the Air Power Development Centre (APDC) published *Beyond the Planned Air Force: Thoughts on Future Drivers and Disruptors* (BPAF). It is a document that challenges the Royal Australian Air Force's airmen to embrace the inevitable changes in the future. Technological, societal and environmental disruptors and drivers will require changes in the Air Force approach to generating the air power needed to support Australia's national interests.

BPAF is the latest in a series of official publications designed to expand the perspective of Air Force and look at how we should operate into the future. Plan *Jericho*, released by the former Chief of Air Force in 2015, outlined a broad plan to make Air Force an agile, adaptive component of the joint force which will be required in the information age—a 5th-generation air force. Jericho continues to drive the development of a culture of innovation in Air Force. In 2016, the *Defence White Paper 2016* and the *Integrated Investment Program* described the capabilities that will define Australian air power for the foreseeable future. These systems will be employed as part of an integrated joint force developed along the five vectors defined in the recently released *Air Force Strategy 2017-2027*. This combination of cutting-edge capabilities integrated into a joint force by an adaptive and innovative organisational culture is the vision for the Air Force. But where do we go from there? BPAF peers beyond this planned force and prepares to extend the five vectors of the *Air Force Strategy* beyond 2027 into an uncertain future.

The importance of looking beyond the foreseeable into the realm of anticipation is important in the current age of rapid change. Though Air Force has charted its preferred path into the near-future, we should not expect that the future will progress exactly as planned. New

technologies, societal pressures, strategic shifts and environmental change will work in isolation, or in combination, to disrupt our plans, for better or for worse. Though the specifics may surprise us, we must be prepared to adapt rapidly and effectively to the opportunities that future uncertainty presents. To do this, we must plan for disruption and not rest assured on the continued validity of our current assumptions.

What is disruption?

Disruption refers to a development that prevents a system from continuing as expected. This can take many forms and can either evolve from observed trends or from a completely unexpected 'black swan' event. Regardless of the form when disruption occurs, Air Force will need to adapt to ensure that it continues to provide the air power required by Government to protect and further Australia's national interests.

Despite the apparent novelty of 'disruptive innovation' as a catchphrase, examples abound in military history of disruptive developments requiring adaptation, either rapid or gradual, for military forces to remain effective, efficient and relevant. The arrival of gunpowder in the West, the harnessing of steam power, the societal and strategic repercussions of the French Revolution, the introduction of aviation and the splitting of the atom have all required changes in the way military power is developed, managed and employed in pursuit of national interests. Indeed, the advent of air power was itself a disruptive event.

Though disruption may not be a new phenomenon, the development of organisational approaches that seek to harness disruption's positive effects and minimise potential threats reflects a shift in attitude towards uncertainty within Air Force. In a way, BPAF is itself a disruptor; it is an official document that does not lay down a plan and does not presume to predict the Air Force of the future. In fact, this is the key concept that drove the development of BPAF; we cannot predict the future but we can be confident that we will be required to adapt in some way. The key to our future success is being able to anticipate the need for adaptation and be able to respond to disruption quickly, effectively and efficiently when it occurs. To do this, Air Force needs to develop creative and critical thinkers.

What *Beyond the Planned Air Force* is and what it is not?

BPAF identifies a number of potential disruptors that may affect future Air Force. The disruptors listed in BPAF range from technological advances in quantum technology and artificial intelligence, through to the potential of environmental and societal disruption resulting from climate change and demographic shifts. The initial list of topics was selected by the staff of APDC, in consultation with the Defence Science and Technology Group, from reviews of defence, business, and technology forecasts. This list is not exhaustive, nor is it intended to be. The possibilities for disruption are not bounded by our ability to identify and articulate the risks as we see them at a specific moment in time. Instead, BPAF provides a sample of some of the more notable factors that we can see shaping Air Force into the foreseeable future. The challenge now is for the men and women of Air Force to continue to scan the horizon for developments that provide opportunities, create threats or simply require our organisation to adapt to a new and emerging reality.

This is more easily said than done. With such a broad arc of future possibilities, we cannot expect our airmen to understand and appreciate the full spectrum of disruptive developments that may emerge. Accordingly, the publication of BPAF is just the first step. Over next few years, APDC will publish a series of papers that explore the potential impact of specific disruptors on Australian air power. These 'BPAF Papers' will provide our airmen with an in-depth understanding of various technological, societal and environmental disruptors, and how they may influence the development, management and employment of air power into the future. Just as importantly, the 'BPAF Papers' will be developed through a series of lectures and workshops that will take place across Australia to engage airmen in the development process, gaining their insights into how those on the air power coal-face see their future changing in light of potential disruption.

BPAF is not a prediction of what the future will be, nor is it a development plan or force design document for Air Force beyond 2027. Instead, it aims to promote discussion, and creative and critical thought about the future of Australian air power. Accordingly, BPAF must not be seen as a policy document or a roadmap, but as a catalyst that should spark the imaginations of today's airmen in envisioning their Air Force as it may evolve in an uncertain and unpredictable future.

The Future of Flight Simulation and Training (#304)

Key Points

- *Contemporary training is not only required to be realistic but must also encompass the potential to increase the speed, efficiency and knowledge retention of the trainee.*
- *The latest simulators have the ability to evaluate student performance as well as provide mission performance statistics.*
- *Adapting to the different ways in which different people learn and bringing in mobile technology, such as tablet computers, into the learning cycle is becoming increasingly important in training.*

The air forces of the world have always been on the lookout for ways to improve their training to create the next generation of aviators. This has always been the underlying basis for attempts to expand the cognitive learning envelope through the innovative use of technology. The skill sets necessary to operate an advanced high-performance fighter aircraft efficiently are difficult to bring to the necessary levels wherein mission accomplishment and safety are not jeopardised. Over the years, training processes have been developed and fine-tuned to bring the trainee to an acceptable minimum standard. Technological advances in simulation capabilities could now revolutionise the training process being followed in most air forces.

Contemporary training is not only required to be realistic but must also encompass the potential to increase the speed, efficiency and knowledge retention of the trainee. In this arena, simulation capabilities promise to improve traditional training processes and systems. Individual air forces have their own visions of future simulation and training methodology. The ultimate aim of simulation would be to create a combined live, synthetic and blended training environment, in which the operators would be able

to interact with weapon systems in highly dynamic and realistic scenarios. The simulation would depend on the individual air force's concept of the threat scenario that it is likely to face.

The more advanced air forces across the world are pursuing a trajectory of greater interoperability between live and synthetic training, while at the same time attempting to maintain an optimum balance between the two. The RAAF's Exercise *Black Skies* is a step forward in this direction. The balance between the two will determine whether or not a particular 'improved' training process will improve the existing proficiency-base being achieved by the current process.

Irrespective of the ability of an air force to resource the development of simulation capabilities in training, the role of simulation in realistic training is being enhanced at a rapid rate. One of the main factors that is pushing simulation forward is the cost factor. A standing air force is always in the process of training new aircrew in order to sustain the generation of air power at the required rate. While the more sophisticated and tailor-made simulation systems are costly, in the long-term requirement of continuous training to maintain the level of air power needed to sustain national security imperatives, they vastly reduce the cost of training compared to using expensive real-time flying for training. Available statistics indicates that a simulator hour costs about 15 per cent of actual flying hours in a training aircraft. Obviously this ratio will vary significantly from platform to platform and is also dependent on the technological sophistication of the simulator.

Other than cost-savings there are some other obvious advantages that come with simulation. The latest simulators have the ability to evaluate student performance as well as provide mission performance statistics. By monitoring the progress of a student it is possible to move a student through the program at a pace that is individually suited, unlike in live training where it is normal to follow a set pattern. Adapting to new ways in which different people learn and bringing in mobile technology, such as tablet computers, into the learning cycle is becoming increasingly important in training. These provide more efficient ways to train future aviators.

Simulation training uses big data and highly evolved analytic techniques to evaluate the progress of trainees and then use that information to improve the efficiency of the next training mission. However, the collection and analysis of big data has its own difficulties that must be overcome before it can be used optimally. Most defence companies associated with flight simulation have clearly stated that using learning science is the best way forward to improving the training process of students. In this context, adaptive learning with the aid of computers is being used to tailor individual student's learning needs within the future simulation systems.

Simulation is being improved by military forces, the civil aviation sector and the defence industry in a collaborative manner. Research is being undertaken to improve the fidelity of the simulation and training products. There is also a move within the industry to streamline the training sector so that more options could be provided to the primary customer, which is the military aviation group. The military forces focus on combat effectiveness in a live environment and are honed on fourth to fifth generation air combat scenarios. Therefore, industry groups are currently focusing on this need through airborne instrumentation systems. While air combat manoeuvring instrumentation has been used for more than three decades, the technological improvements that are being introduced have made the systems into an entirely new training capability. With the introduction of datalink, the system is now capable of interoperability with a number of training systems and enables secure, relevant and realistic training.

Better performance at an affordable price in simulation has become the watchword for developments in flight simulation training. In order to achieve a reduction in price, a common, open-system architecture for air force simulators, which will function in a secure training environment is being considered by the more advanced air forces. The necessity to interact between simulators of different generation aircraft and between allies, so that information sharing is possible emphasises the need for security. This common approach is also likely to minimise life cycle costs.

There are a number of technological hurdles to be overcome to achieve the vision for future simulation and training. The hurdles have been

identified by the manufacturers and the users as persistent and secure networking, interoperation of live and synthetic systems, leveraging open-system architecture for integrating reality and virtual reality and security and data aggregation.

The legacy simulators are designed for stand-alone training, which is not compatible with the current training needs. Geographic spread and security concerns have become the driving factors in the development of training simulators that are becoming extremely complex, both technologically and in their usage. Connecting simulators to each other to derive maximum benefit have so far yielded only peripheral success. The delivery of high-end training in air combat and development of tactics still remain constrained to the beginning of their spectrum. However, as per hour flying cost of modern aircraft increase exponentially, the future of training will be tilted more towards simulation than live training.

5th-Generation Fighting Airbases (#309)

Key Points

- *Airbases have not evolved in parallel with other Air Force weapon systems.*
- *The core of the 5th-generation airbase should be a modern combat information system.*
- *Evolved 5th-generation airbases will require an evolved specialist workforce to operate them.*

In the near future, the Royal Australian Air Force (RAAF) aims to become a 5th-generation force. A 5th-generation air force provides the necessary capability to win against the increasingly complex and lethal threats to national security in the Information Age.

The *Defence White Paper 2016* posits that over the next 20 years a larger number of regional forces will be able to operate at greater range and with more precision than ever before. The RAAF's new fleet of fifth-generation airborne systems will be able to maintain, for now, capability superiority in the region. Regardless of their capability, all airborne systems must recover to an airbase to regenerate. On the ground, all airborne systems are equally vulnerable to attack. Superior 5th-generation systems and capabilities offer no inherent protection against threats when on the ground. Further, the data-hungry platforms may be more dependent on airbase systems and services than their predecessors. A fifth-generation system, based at a second-generation airbase is no less vulnerable, and is probably more so, than a second-generation aircraft in the same environment.

While the RAAF maintains capability superiority in the air, opponents are likely to seek an asymmetric advantage. Unable to match the RAAF's airborne combat capability, a potential adversary will almost certainly examine whether RAAF airbases present a soft underbelly for targeting with long range missile systems, special operations forces, and/or through other unconventional means.

As regional forces modernise, and technical superiority is less of a factor, the success of the Air Force in a contest will become more reliant on the effectiveness of the regenerative capability of supporting airbases; how quickly aircraft can be recovered, repaired, refuelled, reconfigured, rearmed and data transferred.

Air Force's contribution to future joint warfighting needs to be underpinned by airbases able to defeat threats to themselves and the hosted combat forces, and able to effectively coordinate and provide services critical to the combat effectiveness of the hosted forces.

Ground-based threats to modern airbases are evolving due to, among other things, globalisation, urban encroachment and new military and consumer technologies. Urban encroachment around airbases and expeditionary airfields allows hostile parties to conduct surveillance with minimal risk of detection and to launch surprise attacks. Uninhabited Aerial Vehicles (UAVs) can be used for real-time surveillance and to provide targeting information for easily available conventional weapons such as mortars and rocket-propelled grenades. Weaponised UAVs are now being used in combat to deliver improvised munitions. Precision guided mortar munitions are now being fielded; providing a low-footprint, highly effective system for precision targeting of airbases. Physical security measures implemented to counter intelligence gathering provide no protection for aircraft from stand-off kinetic attack. There is also an increasing threat of cyber attack, denying 5th-generation aircraft access to airbase communications systems essential for missions planning, sustainment and data transmission.

Globally, successive generations of combat aircraft flown by both air force and naval aviators have incorporated progressively more sophisticated avionics to support the aircrew's ability to collate, process and fuse an increasing amount of data to support situational awareness, decision making and response. Since the era of the second-generation jet fighter in the early 1960s, (*Pathfinder No 170* explains the different generations of jet fighters) the platforms from which naval aviators operate—the aircraft carriers—have similarly evolved, incorporating

increasingly sophisticated Combat Management Systems (CMS) to support their own decision-making and warfighting capability.

Wargaming by the US military as early as the 1950s revealed that naval combat systems relying on 'manual track plotting' and 'human-in-the-loop information processing', could not effectively counter contemporary Soviet threats. As a result, the first automated combat information processing system, the Naval Tactical Data System was developed and fielded in 1964. Since then the US has evolved successive generations of systems including Aegis and the Ship Self Defence System Mk1 and Mk2. Royal Australian Navy vessels field similar systems, primarily the Saab 9LV Combat Management System.

In contrast to the evolution of naval support systems, RAAF support platforms—airbases—have not developed automated information processing systems to support their force protection and force generation and sustainment roles.

RAAF airbase commanders are responsible for the provision and coordination of over 200 products, services and effects necessary to protect and enable the generation of air power capability in accordance with a designated air component commander's requirements and priorities. Presently, every aspect of RAAF airbase support requires human-in-the-loop analysis and information processing at each stage of the process, usually within functional 'stove-pipes'. This places at risk the ability of the airbase commander to effectively counter contemporary and emerging threats while concurrently maintaining effective coordinated support to the combat force.

Sixty years of development of naval combat information systems provides Air Force with a roadmap for the development of 5th-generation airbases as essential elements of the fully 5th-generation Air Force. To function effectively in support of 5th-generation aerospace systems, in the face of evolving and proliferating threats, airbases require a modern digital combat information system; able to collate, fuse and distribute information to provide situational awareness and decision support across the airbase and broader Theatre Air Control System. Once the digital core is in place, all other enabling and supporting airbase systems can be

fully digitised and modernised to improve awareness, agility, efficiency and reporting. The outcome will be a far more responsive and effective system of airbases with less reliance on, and demand for, personnel as information sensors and processors.

5th-generation airbases, developed as weapon systems modelled on modern naval combat systems, would require a less numerous but more specialised workforce to operate them. Navy employs general and specialist Combat System Operators for the collection, collation, and dissemination of sensor information, and Maritime Warfare Officers for control and warfighting functions. Air Force, in comparison, does not presently maintain a specialist airbase warfare or airbase systems workforce. The 5th-generation airbase workforce would need to be more highly trained and more invested in airbase functions. Airbase operations may need to be treated, for key functions, as a specialist stream as in other Air Force groups.

Countering Unmanned Aerial Vehicles (#316)

Key Points

- *The employment of small UAVs to carry out targeted attacks is being leveraged by non-state militant groups.*
- *A number of military forces across the world are investigating C-UAV solutions, especially against the smaller UAVs.*
- *Irrespective of whether the threat is intended or unintended, proper regulatory and policing processes must be put in place to secure national airspace.*

Cheap and easy-to-operate unmanned aerial vehicles (UAVs) have proliferated globally over the past decade. The employment of small UAVs was initially restricted to surveillance and reconnaissance but it was not long before their potential to carry out targeted attacks was being leveraged by non-state militant groups. In both Iraq and Syria, the Islamic State (IS) has deployed them for tactical military purposes. This expansion in militant capabilities has necessitated the development of counter-UAV (C-UAV) systems to address this emerging challenge. The trend was underlined by the open displays of C-UAV systems at the recent Eurosatory defence exhibition in Paris.

More than two years ago, the IS started to use commercially available UAVs to carry out attacks with improvised explosive devices (IEDs). Early this year, the Russian Ministry of Defence stated that Russian bases in Syria had been targeted through a mass attack by UAVs. It was also reported that these small UAVs were detected by air defence systems and shot down. Many manufacturers of small UAVs, such as Raytheon, have confirmed that commercially available off-the-shelf unmanned aerial systems can be easily weaponised and used by terrorists to threaten both civilian and military infrastructure.

Other than the use of small UAVs by non-state groups, mainly rebels and terrorists, they also pose a threat to civilian air traffic. Near-miss incidents in civilian airports have reportedly tripled over the past two years alone. The potential exists for UAVs to be used for terrorist attacks on mass gatherings and symbolic targets that are not as well protected as military installations. They have also been employed to facilitate criminal activity, to carryout surveillance before a clandestine operation and also to carry contraband, without fear of the capture of human beings. Perhaps more worrying than any of these scenarios is the potential for small UAVs to create a serious aviation accident through an inadvertent collision with a commercial aircraft that could lead to great loss of life.

The increased threat from cheap and commercially available UAVs has led to more research into the factors involved in ensuring that their employment does not infringe on the safety requirements of commercial aviation as well as to ensure that they do not become part of the arsenal of terrorist and rebel groups. There is a consensus that C-UAV solutions must now be examined and developed, before a large scale accidental catastrophe or intended terrorist attack takes place. There is now a high probability that such an event could take place and that it could not be easily identified or thwarted. Accordingly, a number of military forces across the world have started to investigate C-UAV solutions, especially against the smaller UAVs.

A range of C-UAV technologies has been developed and they cater for different situations. Since the smaller UAVs would be employed in different circumstances, the countermeasures also need to cater for the diversity of their use. Kinetic responses, like the use of guns or missiles may not be an optimum solution when the UAVs are employed in urban, densely populated areas. The countermeasures and concepts of operations being developed include electronic jamming; capturing the UAVs with nets attached to other flying systems; kinetic destruction by shooting them down with bullets or missiles; and the employment of lasers.

The kinetic shoot down of UAVs can be achieved in several ways. Multiple kinds of sensors—electro-optical, infrared, radar, radio-frequency, acoustic and Doppler—can be used to detect, track and engage UAVs and, combined with guns, to shoot them down. This combination is a cost-effective option and can be used as a defence against a relatively inexpensive threat that the smaller UAVs represent. A slightly more sophisticated approach to C-UAVs is the system that uses a small tube-launched, expendable uninhabited system that could be flown individually or in swarms depending on the requirement. This system is equipped with a seeker and warhead and, when coupled with an advanced electronically scanned-array radar, becomes a formidable C-UAV system.

Another method to counter UAVs is through the use of laser technology. Laser effectors have already been used to 'blind'—temporarily or permanently—the surveillance and reconnaissance payload of UAVs. More powerful lasers can be used to incapacitate the system completely, which would be akin to shooting it down. Jamming is also being considered as a viable option to counter uninhabited aerial systems. Frequencies that are commonly used to remotely control and transmit video by small UAVs can be easily jammed. It has been reported that such jamming either makes then land automatically, in which case they can be recovered; or return to their origin point permitting the operator to be tracked.

Experiments are also being conducted for the deployment of 'capture nets'. These are nets fired from the ground, either from a static position or form the roof of a vehicle and deploys to cover an area of 250 meters by 10 meters. The net is capable of capturing UAVs moving up to speeds of 50 meters per second. A novel C-UAV capability is the use of birds of prey that have been trained to attack small UAVs. A YouTube video posted by the Dutch National Police shows an eagle snatching a target UAV from the air.

The C-UAV concept trend is towards preferring non-kinetic or soft-kill solutions like jamming or 'hacking' into the systems. Primarily these activities are more reliable in terms of targeting and also can

be employed against multiple UAV attacks, which is highly probable. Further, jamming small UAVs minimises the risk of collateral damage that would come with the kinetic shoot-down of UAVs with explosive payloads.

The C-UAV systems are being developed on a war footing as the potential for the rapid acquisition and deployment of small UAVs, obtained from open sources, has become an accepted threat to civilian and military activities alike. UAVs, used for benign purposes can pose a threat to commercial aviation, with an increasing number of near-misses being reported in the recent past. More importantly, non-state groups, terrorists and rebels, have started to use UAVs for traditional surveillance and reconnaissance but also to conduct lethal attacks. This trend is not only disruptive but also difficult to counter effectively.

The noticeable trend towards the increased use of UAVs by terrorist and rebel groups such as the IS has also resulted in a growing number of C-UAV solutions being developed. It remains a fact that commercially available small UAVs will continue to proliferate. It is also not deniable that their misuse poses a significant threat to the safety and security of a nation and its people. Whether the threat is unintended, as in the case of the probability of mid-air collisions with commercial aircraft, or an act of terrorism intended to kill people and disrupt normal life, the fact remains that proper regulatory and policing processes must be put in place to secure national airspace. The C-UAV developments are the first steps in this direction.

History

The Myth of the Mirage Spares Embargo (#293)

Key Points

- *The story of a French embargo on the sale of Mirage spares to Australia is a myth.*
- *Air Force must plan and prepare for a possible disruption of supply during times of increased threat.*
- *Australia's geographic position requires specific strategy and plans to mitigate against inherent vulnerabilities.*

There is in Australia an enduring myth that in the 1960s the French Government refused to supply spares and munitions for the Dassault Mirage IIIO fighter aircraft then in RAAF service. The myth suggests that the embargo was imposed because of the Australian involvement in the Vietnam War. In truth, no embargo ever occurred, nor was there any such threat made by Dassault or the French Government.

While the origins of the story are difficult to determine, the perceived consequences of a disruption of supply to a fundamental Air Force capability ensures that the essence, if not the accuracy, of the myth endures. Embargoes on the sale of select military equipment to Australia imposed by the governments of Switzerland and Sweden in the 1960s have only served to fuel inaccurate speculations made in relation to the Mirage aircraft.

The saga began when the French Government initiated a policy shift of its position on the Middle East in 1967. The shift encompassed a withdrawal from Algeria and re-engagement with the Arab nations of the region. This renewed policy also resulted in a reduction of support for Israel as well as an embargo on the sale of military equipment to all nations in the region. While ostensibly applicable across all of the Middle East, it was Israel who suffered the most as a result of this policy shift. Fifty Dassault Mirage III fighters and sixteen patrol boats built in France and paid for by Israel were impounded and retained in France, while all

further military sales in support of the Mirages and other French military equipment, then in service with the Israeli military forces, was stopped.

In response, the Israeli Government sought to acquire weapons and spares for its Dassault aircraft from other nations. This included an approach to the RAAF in August 1967. This approach was not unrealistic. At that point, Australia was domestically manufacturing approximately 15 per cent of the Mirage airframe, 80 per cent of the engine and 5 per cent of the avionic and flight control systems. Increasing the production of certain spares in order to open an export market to Israel was well within the capacity of the Australian aviation industry at the time.

The Israeli request was duly discussed by the Air Board in September 1967. For the Air Board, there was clearly the short term attraction in terms of the potential of spreading the cost of component manufacture across a larger customer base, as well as a longer term potential for sustaining the small Australian aviation industry. However the Air Board had to two concerns: was there an implication of a similar embargo on the sale of munitions and spares to Australia and whether or not the sale of Mirage parts to Israel would be the trigger for such an embargo? It is somewhat surprising that the Air Board would have discussed such a proposal prior to obtaining clear guidance from the Government—and the then Department of External Affairs—on the matter.

By a coincidence, the same agenda for the same meeting when the Israeli proposal was discussed also contained a review of the lead times for overseas-acquired spares for every aircraft then in RAAF service. Not surprisingly, Mirage logistics requirements came under particular scrutiny. It was determined that some 45 per cent of the Mirage sustainment budget was spent on French manufactured equipment and that some 94 per cent of the line items required to maintain that equipment was sole-sourced from French industry. Any disruption of the supply of spares for the Mirage, regardless of its cause, was of great concern. The reliance on overseas suppliers from a region as remote from Australia as France was considered a high risk strategy especially in the advent of a major conflict.

The outcome was that firstly, the Air Board decided to increase the war stock of Mirage spares held in Australia from four to eight months at a

cost of some $8.8 million. Secondly, it was also decided at the meeting to approach the French Government to seek clarification of their position on any possible embargo of Mirage spares and munitions for Australia. While action was being taken based on these decisions, the Air Board received direction from the Government that there would be no supply of military equipment to Israel at that time.

The French response to Australia's question concerning the possibility of an arms embargo is extremely interesting given the enduring nature of the myth. In an October meeting in Paris between senior RAAF officers and the head of the French Aeronautical Material, General Yves Ezanno, the French stated '*there would be no French embargo on arms in any circumstances in which Australia may find itself*'. Ezanno went on to state that the assurance was given in full knowledge of Australia's ongoing involvement in the Vietnam War and appreciation that the RAAF's Mirages could employed as part of the conflict. Furthermore, the French Defence Minister offered to add his assurance in writing, if so desired. This assurance was reiterated in more detail by the French President, Georges Pompidou in 1971.

There are two possible threads that appear to have seeded the French embargo story. The first element was the very real embargo imposed by the Swedish Government on the sale of warheads for the Carl Gustav anti-tank weapon. The second was the embargo by the Swiss Government of the last Pilatus Porter aircraft of the order for the Australian Army. In both cases, these embargoes were directly related to the possible employment of the materiel in Vietnam by the Australian Army.

The consideration of the Air Board into the possibility of arms embargoes and into the broader question of guaranteed supply in times of conflict highlights an enduring challenge for Australian air power. Australia's geostrategic position is both a blessing and a curse. Australia's isolated landmass is free of common borders and any adversary would face complex logistics issues in mounting a serious incursion into its territory. However, Australia's isolation, coupled with a small aviation industry, results in a reliance on oversea supply via long and vulnerable trade routes.

An enduring challenge faced by the Air Force has been the access to aircraft and spares from overseas manufactures.

Threats to the supply of new and replacement airframes as well as spares support are critical matters. From 1913 to 1939, it was aircraft of British origin that formed the backbone of the Australian Flying Corps as well as the successor organisations, the Australian Air Corps and the Royal Australian Air Force. However, this reliance was found to be detrimental when expansion plans in 1936 were delayed due to a lack of capacity within the British aviation industry to supply both the RAF and the RAAF.

Similar examples during World War II and in more recent years have occurred where suppliers have been unable to meet the needs of their national military and that of the ADF simultaneously resulting in shortages of critical spares. The protection of Australia's trade routes, the fostering of the Australian aviation industry and the retention of war stocks remain expensive, but critical, components of Australia's national security strategy.

The Development of Air Force Expeditionary Capability 1939-45 (#295)

Key Points

- *Capability development requires planning, investment, commitment and time.*
- *Sustained expeditionary operations require a complex integrated force capable of generating effects across multiple domains.*
- *While shortfalls at force level can be mitigated by allies in joint operations, the scale and tempo of potential conflicts require a base level of capability to be developed and sustained.*

At the close of World War II the Australian Air Force was the fourth largest air force in the world consisting of 182 000 personnel supporting the operation of 6500 aircraft. Importantly, the Air Force was also comprised of airfield construction squadrons, deployable control and reporting units and other specialised units. In fact, the Air Force of 1945 boasted the comprehensive range of capabilities necessary to mount and sustain a combined expeditionary air campaign in remote areas with no pre-existing infrastructure. This rather advanced level of capability was developed over a period of five years from what was an extremely low level of manpower, skills and equipment.

The poor condition of the Air Force's deployable capability in 1939 was a failure to consider the demands of sustaining deployed air operations. This neglect is reflected in most of the Air Board's planning documents from *Report on the Air Defence of Australia of 1920* and the *Memorandum Regarding the Air Defence of Australia* of 1924. While both of these reports recognised the limited aviation infrastructure across Australia, both failed to address the requirement for operations away from established bases.

While the criticism of the planning in the 1920-30s is in many ways justified, the Air Force was only just beginning to gain an understanding

of the operating conditions to be expected in the strategically important approaches to Australia's north. In 1923, two RAAF officers joined an RAN cruise through the New Guinea and Solomon Islands region and took extensive notes on potential bases and operating conditions in this remote area. The isolation of the region was highlighted when the first Air Force aircraft to operate in the area during 1926 was stranded in the Solomon Islands for 19 days after the engine cracked a cylinder block. So while the Air Force may have been beginning to appreciate the difficulties in operating in remote areas outside of Australia, it would be 13 years before serious efforts were made to begin developing a capability to sustain air operations in what was to become the South West Pacific Area of operations (SWPA) in World War II.

The Air Force's pre-war approach to sustaining operations in areas such as New Guinea and the Solomon Islands was a program to establish a line of advanced operating bases (AOBs) extending out from Australia in an arc to the north extending to the Pacific. The AOBs established the means to sustain an aviation presence in the region. However, as progressive as the AOB concept was, the resultant capability was mostly limited to basic seaplane operations because of the difficulties in building and sustaining airbases so far from the Australian mainland.

While establishing AOBs was an important step in the development of Air Force expeditionary capability, the bases were only part of the requirement. The main shortfall at the time was personnel, and this particular deficiency began to be addressed in earnest by the Air Force from September 1939 onwards. The expansion in the workforce took two forms. First the Air Force was expanding the diversity of the skill within its ranks. For example, in February 1941 the Air Force had 66 separate musterings open to its enlisted personnel. These musterings included aircrew roles as well as traditional air and ground related trades such as electrical fitters and blacksmiths. By 1945 workforce structure had grown to encompass 132 separate musterings including plant operators, coxswains and radar mechanics.

The second form of personnel development became evident as the air campaign in the SWPA opened new fronts and as additional equipment

was acquired. The demands for greater numbers of personnel also increased. These demands were proportional across all the musterings. For example the Air Force went from needing 27 blacksmiths to 160 and from 195 electrical fitters to 1540.

It is perhaps in the new musterings that the demands of expeditionary capability were most evident. In August 1942 during the period of the Battle of Milne Bay, the Air Force had no specialist radar mechanics in uniform despite having fielded a deployable radar unit to the area. However, by August 1945 there were 675 specialist air radar mechanics and a further 634 ground radar specialists supporting a network of radar and reporting units spread along the coast of Australia and extending into the operational areas of the SWPA.

In total the Air Force went from 27 805 enlisted personnel in 1941 to 132 784 in August 1945. While the statistics clearly represent the growth in the size and overall capability of the Air Force, what is not reflected by numbers alone are the requirements to administer, train, and sustain the expanded workforce domestically and on operations. The complexity of the raise, train and sustain function that the Air Force experienced in World War II and how that challenge was overcome is a remarkable story in itself.

The Battle of Milne Bay, 25 August – 6 September 1942, was a defining moment for the Air Force since it highlighted the inadequacy of the Air Force's expeditionary capability. To construct, sustain and protect the three airfields in the Milne Bay area, the Air Force needed the support of the Australian Army, RAN and US airfield engineers. From this pivotal battle the growth in the Air Force ability to sustain itself in the field became ever more evident. At each successive landing in the long process of liberating the SWPA from occupation, the Air Force continued to become a more complex force, not only in the air domain, but in ground and maritime domains as well, with airfield defence squadrons and a fleet of Air Force supply vessels each contributing individually to the air campaign. By the time the Air Force landed at Morotai in September 1945 it boasted a fully capable Tactical Air Force (No 1 TAF) and was operating from multiple bases, constructed and sustained by Air Force personnel.

The sophistication and capability of the Air Force to conduct remote area operations is perhaps illustrated by the example of the American landings in the Philippines in late 1944. The only Australian units that landed as part of the US forces were included to make up for a shortfall in American capability. The two units were the Air Force's No 3 Airfield Construction Squadron (No 3 ACS) and No 6 Wireless Unit (No 6 WU). While the role of No 3 ACS is self-evident, that of No 3 WU is less so. A highly specialised radio intercept unit, its work during the Philippines operation is credited with the destruction of 17 enemy ships and the interception of numerous air raids. In the closing days of World War II the Air Force had turned around the expeditionary equation. From a supported element it had transformed itself into a highly effective independent force capable of supporting any campaign.

RAAF's First Spacecraft Intercept Mission (#296)

Key Points

- *Whilst this event is not strictly a space intercept, it illustrates the flexibility and adaptability of air power, to be applied at short notice, to meet new and unexpected mission needs.*
- *The ability to rapidly access imagery to validate the Buran had a significant effect on public perceptions of the RAAF's response capabilities.*
- *At the height of the Cold War, developments in space technology were closely guarded secrets.*

At the height of the Cold War, on 3 June 1982, the crew of a RAAF P-3C Orion captured the first images available to the West of a new and previously unseen Soviet spacecraft. The spacecraft had splashed down near the Cocos Islands and was being retrieved by a Soviet recovery ship. The BOR-4[1] No 404 Buran (meaning Snowstorm) spacecraft was a 1:2 scale prototype model of the Spiral VTHL (Vertical Take-off Horizontal Landing) craft. The Spiral VTHL was meant to meet Soviet design requirements for the development of a reusable spaceplane that could deploy and recover payloads from an Earth orbit. BOR-4 was designed at the Gromov Flight Research Institute and manufactured by NPO Molniya.

The USSR was considering designs for a space shuttle to support future military missions into space, provide maintenance to orbiting space missions, deliver and recover cosmonauts from orbit, deploy modules for a large orbiting space station, and to carry scientific sensor payloads and passengers on ground-space-ground trajectories. The maximum planned orbital altitude of the Buran

1 Bespilotnyi Orbital'nyi Raketoplan 4 translates as "Unpiloted Orbital Rocketplane 4"

craft was 250 km with a maximum payload of 30 tonnes and eight tonnes of rocket propellant.

Although full-scale variants of Buran were flight-tested in the atmosphere by trained pilots, the first and only space orbital flight was made without a crew. BOR-4 subscale spacecraft were developed in order to test the survivability of the Buran heat shield. Available equipment was inadequate to validate the heat shield in the lab as it couldn't replicate the plasma sheath that envelopes spacecraft travelling at hypersonic speeds on atmospheric re-entry.

Launched from Kapustin Yar with the space mission designator COSMOS-1374, and after completing one Earth orbit, the spacecraft was deorbited and performed a gliding re-entry before deploying a parachute for a splashdown in the Indian Ocean. Subsequent recovery was effected by a Soviet Navy task force. Seven Soviet ships were deployed into the Indian Ocean to support the first BOR-4 orbital mission, including a Krivak II FFG from the Black Sea Fleet, three Chumikan-class space tracking support ships, a Sesna-class auxiliary, and three spacecraft recovery vessels.

The RAAF deployed P-3 crews to Cocos Island under Operation *Caterpillar* at short notice to conduct maritime surveillance during the period 1 to 9 June 1982 in order to find the Soviet ships and monitor the BOR-4 recovery mission. No 10 Squadron exercised operational command with four of its crews, 492 Squadron maintenance teams, and two US Navy aircraft. The BOR-4 splashed down about 300 Nm south of Cocos Islands. The RAAF P-3 Orion gained close-up imagery of the BOR-4 spacecraft floating in the Indian Ocean after splashdown and the efforts by the Soviet recovery vessel crew to retrieve it. The Australian imagery was released publicly and was widely published in the Western press as an intelligence coup by the RAAF.

One Soviet crew member commented on the impact of the release of the Australian P-3 Orion aerial photography, taken while he was performing seemingly insignificant ship's kitchen duties,

> ... I was at the potato drudgery, assisting the cook master. Early in the morning before the beginning of the drudgery was a large tank of waste. We did not want to move it to the dumpster, this is why we poured all by the port-hole. Nobody noticed anything, but during the evening the commander of the flotilla received remonstrances from Moscow. In fact Orion which flew to a few kilometres of the ship had photographed the floating waste on the sea. They developed the film and one submits a report with the commander of the military base in Australia by specifying that the Russian ships had rejected to the sea a thing impossible to identify. From Australia the message went to the USA then to Brussels. A protest note left Belgium to Moscow, specifying that it was intolerable that the Russian ships reject substances to the sea. Lastly, Moscow contacted the base of Petropavolsk in Kamchatka and the latter the Tsoumicana ship to order an investigation right away. And all that in one day space." Nobody would have thought that the rejection of a kitchen dustbin would have so much political resonance![2]

During the period 6 to 19 March 1983, RAAF again deployed P-3 Orions from No 10 and 11 Squadrons at short notice under Operation *Enquarter* to conduct surveillance against a second Soviet Buran BOR-4 No 402 space mission. This mission was designated COSMOS-1445 and was launched on 15 March 1983 for an eventual recovery in the Indian Ocean. Once again, RAAF successfully gained imagery of the Soviet recovery efforts when the spacecraft splashed down about 250 Nm south of Cocos Islands.

RAAF P-3 imagery was shared with the USA. Subsequent analyses resulted in the US construction of a model for wind tunnel testing. US trials showed that the slanted wings gave the BOR-4 vehicle good stability, and that its shape offered good turning and gliding capability. These design characteristics may have been exploited in design considerations for later US space glider designs such as "Dream Chaser."

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2 Buran-Energia. www.buran-energia.com/bor/bor-recup.php

The USSR launched its first full-scale reusable Buran on 15 November 1988 using 'Energia,' then the largest available Soviet-made space launch vehicle. The first full-size Buran spaceflight trial completed two orbits before performing a controlled re-entry and successful landing in automatic mode at an aerodrome in Baikonur. Two full-scale Buran spacecraft were manufactured. However, the Soviet space priorities had changed and the USSR cancelled the Buran program after the one successful unpiloted space mission.

After the break-up of the Soviet Union, the two Buran spacecraft became the state property of Kazakhstan: the spacecraft that had flown a space mission was destroyed in a 2002 building collapse, the second spacecraft is an interactive museum at Gorky Park.

Baron Manfred Von Richthofen: A Deadly Practitioner Of Early Air Doctrine (#307)

Baron Manfred von Richthofen was killed in air combat on 21 April 1918. He is one of the most celebrated air warriors in the history of air combat having shot down 80 enemy aircraft during World War I. The British called him the 'Red Baron'; the French called him the 'Red Devil'; and Australia's official war historian C E W Bean described him as the "star of stars in the German Air Force." He was both feared and respected as the highest scoring air ace of World War I.

One of the reasons behind his success in air combat was his adherence to doctrinal maxims that guided his judgement in deciding when and how he would enter the battlespace and also the selection of the target to engage. Richthofen strictly followed 'Dicta Boelcke' as tactical doctrine to guide his decisions in the battlespace.

'Dicta Boelcke' is a set of tenets or maxims on air combat developed by Oswald Boelcke, Germany's first air ace in World War I, who scored a total of forty victories. Boelke was Richthofen's mentor, instructor, squadron commander and friend. But his legacy extends far beyond his relationship with his famous pupil. Richthofen wrote of Boelke that, "We were all beginners. None of us had had a success so far. Consequently, everything that Boelcke told us, was to us, gospel truth."

Key Points

- *Richthofen diligently applied tactical doctrine, 'Dicta Boelke', to achieve his 80 air combat victories*
- *Richthofen being shot down is attributed to a medical condition that impaired his judgement, causing him to break one of his own maxims of air warfare.*
- *Air Force doctrine is a living document, and an evolving articulation of what is the collective and authoritative wisdom learned from over 100 years of Australian air operations experience.*

Boelke's character, leadership, organisational genius, as well as his development of air-to-air tactics and their impact on aerial doctrine, have ensured that Boelcke remains an inspiring figure in air warfare history, to this day.

While commanders were still seeking to understand roles for aircraft as the newest war machines to enter the battlespace, Boelcke was the first fighter ace to apply critical thinking to air combat.

Boelcke drew on his own observations of his successes and failures in aerial combat, and analysed them to identify the critical decision points and pilot behaviour. He examined tactics and decided which could be further refined to improve the probability of success in future aerial combat. He personally tested and evaluated the 'rules' he formulated before recommending them as "rules for success" that should be adopted by pilots flying in air combat as individuals or as a group in a squadron.

This was the first time that air combat had been analysed to identify and recommend best-practices that would form the foundational maxims for air combat doctrine. His aerial warfighting principles were endorsed by the German Air Force to all airmen, including the Red Baron, as 'Dicta Boelcke.'

'Dicta Boelcke' was published by the German military in a pamphlet and distributed as a training manual on fighter tactics to each pilot upon graduating from fighter pilot training, prior to being posted to a "Jasta"—a WWI German fighter squadron. Richthofen and other German pilots used Dicta Boelcke as an early form of tactical doctrine.

Richthofen fully embraced 'Dicta Boelcke.' After gaining further experience and some victories in aerial combat, he applied critical-thinking to identify gaps in the maxims in order to improve and complement tactical doctrine. One of his own doctrinal maxims that complemented 'Dicta Boelcke' was to "never obstinately stay with an opponent" This meant knowing the decision-point when an attack should be broken off as the situation evolved to no longer being favourable. He did not adhere to this principle on his final mission.

On 21 April 1918, Richthofen pursued a Sopwith Camel piloted by novice pilot, Lieutenant Wilfrid May. May was in combat with a fellow novice pilot, Richthofen's cousin, Lieutenant Wolfram von Richthofen.

Upon seeing his cousin being attacked, Richthofen flew to his aid and started to pursue May. With Richthofen in pursuit, May disengaged from his dogfight with Wolfram von Richthofen.

At this point in the aerial combat, another Sopwith Camel piloted by Canadian Captain Arthur "Roy" Brown engaged Richthofen. Richthofen evaded this initial attack by Brown and resumed his pursuit of May who was descending rapidly to move away from the battlespace in order to escape the German Ace.

May would later explain that his aircraft guns had jammed while being pursued and, unable to out-manoeuvre Richthofen, he decided to fly low into friendly territory, in order to "make a dash for a landing as his only hope."

At this stage, Richthofen appeared to break his own rules and those of Boelke, that he had consistently applied in air combat. Ignoring all else except his quarry, he followed May down to very low altitude over enemy lines, and within range of machine-gunners in the Australian trenches. Richthofen was fatally wounded by a single .303 bullet fired from the ground. He managed to make a controlled landing before dying in the cockpit, in Australian-held territory. The reasons as to why he made a judgement error in his last dogfight, leading to his death, are still debated.

Forensic medical analysts have reviewed medical records and observations of Richthofen's behaviours in the months leading up to his last combat mission. They have generally concluded that he seemed to suffer from an uncharacteristic episode of "target fixation" in breaking his own rules of air combat to "never obstinately stay with an opponent." Medical researchers have since attributed that uncharacteristic error in judgement to a head injury that might have persisted from a head wound caused by a machine gun projectile during a dogfight that occurred nine months earlier.

Irrespective of the cause of his deviation from established doctrine, Richthofen's decision to ignore the 'rules', that had been drawn from his own experiences, and proven to be tried and tested in air combat, contributed to his demise even though he was the highest scoring air ace of World War I.

Doctrine is drawn from the analyses of observations taken from experiences. Success in war, campaigns or tactical engagements are analysed to identify and recommend repeatable best-practices.

Doctrine describes what a military force believes to be the best way to conduct military operations at various levels of command. Military doctrine describes accepted and officially endorsed fundamental principles that guide the decisions of warfighters and their actions in the battlespace. Air power doctrine describes the best ways for efficiently applying air power and effectively delivering effects from, and in, the air domain. It is applicable to all warfighters, irrespective of their level of combat experiences. However, doctrine may be prescribed differently at different levels of a military organisaiton – tactical, operational, and strategic - depending on the perspective and span of decision responsibility.

Ideally, doctrine should enjoy a degree of stability, as it is built upon an analysis of lessons learned from operations. Changes to doctrine should only occur as new experience expands the available source of data to inform it, or if there are changes in the character and conduct of war or technology. The longevity of well-crafted doctrine is reflected in the fact that ‘

’ were issued to Luftwaffe pilots in World War II fighters and were used by pilots in the Korean War.

However, the World War II era air combat doctrine began to lose its relevance with the introduction of modern combat aircraft equipped with ‘beyond visual range’ sensors and weapons. This reflects the fact that doctrinal concepts are not immutable physical laws but are interpretations of evidence-based analyses of the battlespace. As the character of the battlespace and/or the conduct or aerial warfare changes, the evidence-based analyses should be updated. Air warfare, and the application of air power, must keep pace with the changes observed in the battlespace.

Developed from experience and tested on operations, doctrine offers both guidance for the novice, as was the case with the German pilots arriving on the battlefield soon after completing their training, and for more experienced professionals, such as Richthofen in 1918. Doctrine remains a critical enabler of professional mastery regardless of experience, and it can only be ignored and violated at one’s own peril.

The Role of History in Educating Air Power Strategists (#314)

Key Points

- *Even though history may not provide clear lessons, the study of the past offers a lens through which to analyse, understand and reflect on the challenges currently faced by modern air forces*
- *History could be considered a rather dynamic field of study, one where historians continually re-examine evidence and re-interpret the past.*
- *It is recognised that 'strategic principles are derived from the study of history'*

What is history? What is its relevance to an air power strategist? These are important questions; however, as Richard Muller, a senior member of the faculty at the US Air Force's School of Advanced Air and Space Studies, reflected in 2016, 'as a rule air forces have not embraced historical study to the same extent as have their army or navy counterparts.' Nevertheless, in 1912, a year after an Italian aeroplane dropped the first 'bomb' over Libya, noted US naval historian and strategist Alfred Thayer Mahan reflected on the link between military history and 'sound military conclusions.' However, history does not provide clear lessons, nevertheless, the study of the past offers a lens through which to analyse, understand and reflect on the challenges currently faced by modern air forces.

This *Pathfinder* considers some of the issues related to applied military history beginning with an outline of the purpose of history and the challenges of applying the past to the present. It also considers how air forces have used the study of the past as a tool for education while concluding with some tentative thoughts on how history can be used to educate strategists in the continuing challenge to achieve professional mastery.

To start with, the term 'education' is used in this narrative in a broad context and incorporates both formal and informal learning. Similarly,

the term 'strategist' is used in a collegiate manner and assumes that modern air forces seek personnel who are professional masters, well-versed in the core knowledge that underpins the application of air power.

As the British historian John Tosh reflected, the term history is ambiguous at best. Is history a collection of facts related to what has happened or is it the scholarly discussion and representation of the past? If the latter statement is accepted as being correct, then it can also be assumed that the interpretation of the past is an argument without an end. While a hackneyed observation, history is a dynamic field of study, one where historians continually re-examine evidence and re-interpret the past. Linked to this is the extent of historical information available to historians and, by default, strategists who seek to apply lessons from the past to the present. The archival records and evidence that underpin the interpretation of the past are normally incomplete. For example, the National Archives of Australia only preserves a small amount of the material generated by the Australian Government.

Moving beyond the above understanding of history, the field of military history can be split into three subfields: popular, academic, and applied history. There is a degree of overlap between the latter two. The main criticism of applied military history is that it is a form of weaponising the past to cater for the present. Underpinning this criticism is a view that those writing such history do so without sufficient understanding of the context in seeking to deduce lessons learnt. Unfortunately, this criticism is currently directed at academics working at institutions delivering professional military education. These institutions use history to illuminate and provide context to the ambiguous challenges that officers attending them are likely to confront in the future.

Historically, the criticism of weaponising the past does carry some weight, and therefore air power strategists could be criticised for the poor use of history to support their arguments. Indeed, as Sir Michael Howard, a distinguished military historian, noted in his 1961 lecture on *The Use and Abuse of Military History*, '[W]hen great [interwar]

pioneers of air war…advocated striking at the homeland and at the morale of the enemy people…they were basing their conclusions on *their* interpretation of past wars'. (emphasis added)

More recently, Colonel (retired) John Warden III's book, *The Air Campaign*, has been criticised for his use of a selective reading of history to fit the theory being propounded in it. Admittedly, Warden is not a historian. However, such selective use of history becomes problematic to the broader task of delivering professional education when such texts appear in, for example, Staff College reading lists where they can reinforce a narrow, and at times wrong, understanding of some of the officers they are meant to educate. Despite this criticism, it is clear that many air power thinkers have recognised the value of a broad reading of history. For example, in a 1921 article on 'Strategy and Air Strategy,' Group Captain John Chamier of the RAF reflected on the challenge of deducing appropriate principles for the use of air power given the brief history of air warfare till then. Nevertheless, Chamier recognised that 'strategic principles are derived from the study of history', and he recognised that examples from 'naval and military strategy' could provide the necessary framework for a discussion of 'air strategy.'

While history and the application of its lessons by air forces is fraught with challenges, its importance as a didactic tool for the military cannot be underestimated. Indeed, the study of history has been, and remains, an element of the curricula at educational establishments of most air forces. However, considered in a broad manner, the study of history has been unbalanced. For example, in the late-1940s and 1950s, history and related subjects featured little on the curriculum at the Royal Australian Air Force College. As Alan Stephens has noted, the RAAF of this period identified itself as a 'narrow technocracy' with knowledge of the Air Force's core business to be deduced from its 'technical components' rather than a 'study of its history and ideas.'

There are several areas where the contemporary study of history plays a key role in the education of air power theorists and strategists.

Perhaps most important is that a deep and contextual study of history provides an important understanding for military personnel seeking to gain professional mastery of the profession of arms. Indeed, if it is accepted that the aim of learning is to develop the cognitive ability to understand and deal with ambiguity, rather than to provide clear-cut answers to current problems, then the study of history has a role to play.

The skills associated with historical analysis refines human cognitive areas such as the ability to make considered judgements. An important contributor to the effectiveness of this learning process has been the increasing civilianisation of the academic delivery at institutions catering to professional military education. At a practical level, the use of Staff Rides as a learning tool could also ensure that history could be used as a means to explore ideas outside of the confines of the traditional education environment. However, this process also has its own challenges. In the final analysis, Lieutenant General Sir John Kiszely's remark that the study of history needs to form an essential part of a 'balanced diet' of education for the military professional in order for them to develop the knowledge to be effective, rings completely true.

'The word *history* carries two meanings […] It refers both to what actually happened in the past and to the representation of that past in the work of historians.'

—John Tosh, *The Pursuit of History*, 1999, p. viii.

World War I: The Cradle of Air Power (#317)

Key Points

- *The fundamental characteristics and roles of air power were establish during World War I.*
- *There is an unbroken chain linking the modern understanding of air power to the events of 1914-18.*
- *The application of air power will continue to evolve in line with threats and opportunities created by a combination of technology and human decision-making.*

As the Air Force moves towards its preferred future through Plan *Jericho* it is tempting to perceive air power as a modern concept which has only now evolved to a sophisticated form after more than a century of powered flight. However, history shows us that while the general perception of military aviation 1914–18 is of aces living short but daring lives is not altogether inaccurate, what is frequently missed in the narrative is the rapidity with which military flying became a complex weapon of war. The use of the air to further wider objectives as opposed to the simple use of aircraft to generate effects in the land or maritime domains was evident as early as 1915 when Britain, France and Germany conducted strikes against targets outside of immediate war zones.

The potential for aviation to change the conduct of conflict was well appreciated in the years leading to World War I. At the Hague Convention of July 1899, such were the concerns regarding the threats posed to civilian towns and other 'undefended' targets by aviation, the delegates agreed to a declaration banning—for five years—the discharge of projectiles and explosives from balloons or by other platforms in the air. At the second Hague Convention of 1907 the declaration was reaffirmed. The considerations of the Hague Conventions were timely since in 1911 aircraft were used operationally for the first time by Italy during the Italo-Turkish War.

Initially in the reconnaissance role, by November aircraft were being used to conduct bombing strikes on Turkish positions. The Italian aviation commander during the Italo-Turkish War and in World War I, Julio Douhet, was to write a seminal work on the nature of air power in 1921 titled *The Command of the Air*. While intended to address Italy's defence needs, many see in this work the seeds of the strategic bombing campaign of World War II.

Clearly, the great powers were all well aware of the potential for aircraft to pursue war aims beyond the immediate battlespace to the extent that civilian assets could become targets. The initial response was to limit such threats through the Hague Conventions. However, by 1914 only the Governments of the UK, USA, Portugal and Belgium had ratified the agreement. The realities of total war in 1914 changed such notions of limiting warfare to military targets to the extent that by January 1915 both Britain and Germany had conducted air raids on their adversary's cities. Any consideration regarding the potential for civilian casualties was rationalised by focusing on the military nature of the targets selected.

By 1917, such were the deprivations caused by German fixed wing and airship attacks on London that the national will to continue the war against Germany was thought to be threatened. The nature of this debate in the UK in part mirrors Douhet's 1921 thoughts on strategic bombing and informs the more refined modern doctrine of effects-based targeting.

At the operational level, the threat posed by German airships to Britain resulted in the Royal Naval Air Service, as early as September 1914, developing an offensive/defensive control of the air strategy based on attacks on enemy airbases, interception of air raids, active defensive measures such as anti-aircraft batteries and passive defence such as the use of blackouts. The first of the Smuts Reports of 1917 (see Pathfinder 43) further directed the development of the UK's integrated air defence system—an enhanced version of which was employed during the Battle of Britain 23 years later—with radar being the only element missing in

1917. The second Smuts report recommended the establishment of the Royal Air Force as an independent arm of Britain's armed services.

Within the ground campaign on the Western and Eastern Fronts, the use of aircraft for reconnaissance purposes quickly developed into a practical tool for informed decision-making. The successful British retreat from Mons, the French victory at the Battle of Marne and the German encirclement and subsequent victory over Russian forces at the Battle of Tannenburg were all, in part, influenced by intelligence gained from the air.

When Australian forces landed at Gallipoli in April 1915 they were supplied with aerial reconnaissance images from the Royal Naval Air Service (RNAS). The reconnaissance capability in theatre included the purpose built seaplane carrier HMS *Ark Royal* as well as deployable aerial camera and film processing units complete with image analysts and intelligence officers.

Aerial observation was further enhanced through the use of radio. As early as 1912, British airships equipped with transmitters demonstrated the effectiveness of aerial observation during prewar exercises. In one prophetic instance Lt Gen Douglas Haig was out maneuvered and soundly beaten during an exercise in July 1912 by Lt Gen Sir James Grierson who had near constant intelligence reports transmitted to him from an airship.

By 1917, the Australian Flying Corps (AFC) No 1 SQN was routinely employing radio equipped aircraft in Palestine and, later on the Western Front, the AFC's No 3 SQN employed radios on a daily basis. While the use of radio was employed for artillery and observation reports on ground forces, new and effective uses were continually found. For example, during a period of British air superiority in the second half of 1918, No 3 SQN aircraft began reporting on attempts by German aircraft to establish local air control. As enemy formations were located, their tracks were reported and RAF Sopwith Camels were duly sent to intercept the interlopers. This early form of AEW&C, while rudimentary at best, was a forecast of the potential for later developments.

The threat posed by unlimited observation by aircraft naturally resulted in the concept of control of the air over friendly territory while maintaining freedom of operations over the adversary. From this simple concept the doctrine of air superiority developed. When, in 1915, French pilot Roland Garros modified his aircraft to fire a machine gun through his propeller arc he set a precedent for combining the act of flying the aircraft with that of targeting another aircraft. The Fokker *Eindecker E1* fighter further developed the concept when it was fitted with the first successful 'interrupter mechanism', which harmonised the firing of the machine gun with the movement of each propeller blade. This, the first airborne weapons system essentially integrated the aircraft's power plant, weapon and flight controls with the act of flying, aiming and operating the gun—all of which was centrally controlled by the pilot.

The development of practical fighters resulted in pressure being applied to the aviation industry to produce aircraft with ever more powerful engines and expanded flight envelops. As in the 21st century, the battle for control of the air in World War I was fought out as much in the design houses of aircraft manufactures as it was in the air.

The experience of employing air power over the last 105 years has enshrined the characteristics and roles of air power in doctrine and in campaign planning. While the technology and performance of 5th generation air forces have long since exceeded those of 1914, the essential nature of conflict and that of the employment of air power has remained constant. What evolves and generates change are the 'ways and means' in which adaptive human responses in combination with technology has created opportunities and threats which in turn has forced change to organisation, capability and plans.

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"Heron Eyes". Winner 2012 RAAF Heritage Awards Painting by Ben Patynowski (2012).