# PATHFINDER

COLLECTION – VOLUME 7

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# Foreword

In June 2004, the Air Power Development Centre commenced publication of a fortnightly bulletin called *Pathfinder* with the express intention of placing contemporary issues, and challenges that face air power, in the public domain for discussion and debate. Alternating with contemporary topics, the *Pathfinders* also examined the varied aspects of the history of the RAAF. It is a matter of great pride for us here at the APDC that in the 12 years that have since past we have not missed a single issue. We will endeavour to continue this tradition.

All matters about and around air power are open for consideration in the *Pathfinder* series: strategy, historical analysis, operations, administration, logistics, education, training, people, command and control, capabilities, technology and so on. The list of topics is almost endless. We at the APDC are always looking for contributions from outside to enhance the quality and expand the spread of topics that are discussed.

This is the seventh volume in the *Pathfinder Collection* series. The contemporary air power related articles in this volume demonstrate the progress the Air Force has made in inducting and sustaining technologically sophisticated air power capabilities. Generally, the topics discussed point towards the Air Force's journey in becoming a truly 5th-generation force. Similarly, the historical ones recall the splendid history of the RAAF. As the second oldest air force in the world, it is only natural that our history is something that we should proudly reflect upon and hold close to our hearts.

This volume will be a valuable addition to the earlier collections that have been extremely well received. I commend this volume to you.

GPCAPT Mark Green
Director, APDC
August 2016

# 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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# Contents


*Foreword* . . . . . . . . . . *v*

*The Air Power Development Centre* . . . . . . . . . . *vii*

**Air Power**

Future Air Combat Platforms (#217) . . . . . . . . . . 3

Next Generation Unmanned Aerial Vehicles (#223) . . . . . . . . . . 7

Manned or Unmanned? The Future of Air Power Delivery (#237) . . . 11

Uninhabited Combat Aerial Vehicles and Artificial Intelligence (#242) . . . . . . . . . . 15

Automated Aircraft Systems: To Crew or not to Crew, That is the Question (#243) . . . . . . . . . . 19

Uninhabited Aerial Vehicles: Possible Future Developments (#249) . . 23

Lighter-Than-Air and Hybrid Airships (#225) . . . . . . . . . . 27

The Combination of Precision, Speed and Reach: A Unique Air Power Capability (#221) . . . . . . . . . . 31

Critical Mass and Air Power (#229) . . . . . . . . . . 35

Sustainability of Air Power (#231) . . . . . . . . . . 39

Air Power: Underpinning Modern Military Forces (#235) . . . . . . . . . . 43

Long-Range Strike: A Foundation of Power Projection (#251) . . . . . . . 47

Air Power and Collateral Damage: The Debate Continues (#247) . . . . 51

The Relevance of the Concept of Strategic Bombing (#245) . . . . . . . . . 55

Air Power and the Information Domain (#227) . . . . . . . . . . 59

National Security and High-End Air Power Capabilities (#219) . . . . . . 63

The Continuing Criticality of Air Power to National Security (#240) . 67

Space: Use, Weaponisation and Legalities (#233) . . . . . . . . . . 71

**History**

The RAAF's Strike Capability PART I: Developments up to the end of World War II (#218) . . . . . . . . . . 77

The RAAF's Strike Capability Part II: Development 1945–2014 (#220) . . . . . . . . . . 81

The RAAF's First Experience with Rotary Wing Aircraft (#226) . . . . . . 85
The RAAF Rotary Wing Experience: Preparing for War (#228) . . . . . . 89
RAAF Helicopter Operations Vietnam 1966-71 (#230) . . . . . . . . . . . . . 93
The Australian Flying Corps: Part I (#246) . . . . . . . . . . . . . . . . . . . . . . . . 97
The Australian Flying Corps: Part II (#248) . . . . . . . . . . . . . . . . . . . . . . 101
Australian Flying Corps in New Guinea (#234) . . . . . . . . . . . . . . . . . . . . 105
RAAF Liberators and Long-Range Strikes (#222) . . . . . . . . . . . . . . . . . . 109
The P-3 Orion in RAAF Service:
Flexible Air Power in Action (#250) . . . . . . . . . . . . . . . . . . . . . . . . . . . . 113
C-130A: Agent of Transformation (#250) . . . . . . . . . . . . . . . . . . . . . . . . . 117
The Selection and Construction of the CAC Sabre
for RAAF Service (#236) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 121
Combat Control in the RAAF (#224) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 125
Air Power's Contribution to Preserving Cultural Heritage (#238) . . . 129
Officer Cadet School Portsea: The RAAF Experience (#244) . . . . . . . 133
The Defence Restructure 1976 (#239) . . . . . . . . . . . . . . . . . . . . . . . . . . . 137
The Father of RAAF Radar:
Air Commodore Alfred Pither, CBE (#252) . . . . . . . . . . . . . . . . . . . . . 141
RAAF Involvement In Nuclear Testing (#232) . . . . . . . . . . . . . . . . . . . . 145

**List of Contributors** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 151

**Index** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 155

# Air Power

*One of the most important lessons of strategic bombing [long-range precision air strike] which still has to be learned fully is that target priority systems are meaningless unless target intelligence is hard and up-to-date.*

Asher Lee, *Air Power*, 1955 p.19

# Future Air Combat Platforms (#217)

> **Key Points**
> - *Sixth generation air combat capability is already being thought of as a necessity*
> - *Hypersonic flight and 'speed of light' weapons will continue to be unavailable in the next 30 years*
> - *Inhabited and uninhabited platforms will operate in concert with each other in future air combat missions*

Fifth generation fighters that have created a quantum leap in air combat capabilities are now operational and a number of air forces are in the process of acquiring these capabilities. Air forces of calibre around the world are already undertaking careful analysis to determine the kind of air combat capability that they would need post-2035 or so, to ensure a capability edge into the future to meet their responsibilities within the national security equation. This analysis is now being superimposed with the debate regarding the financial outlay required to meet the projected quantum and kind of air combat capability that modern air forces consider to be necessary to meet the demands placed on them. This debate has two sides to it—one that supports the induction of the latest, fifth generation aircraft and thereafter looking forward to the sixth generation; and the other that supports the adoption of a cheaper, multi-role platform that would provide a '75% solution', a generation of aircraft that could perhaps be labelled 'generation four plus-plus'.

The debate regarding what would be the appropriate air combat capability for a particular air force and nation will no doubt continue for sometime without ever arriving at a satisfactory conclusion. However, in the wake of fifth generation technology proliferation, a sixth generation air combat platform is already being considered a necessity by most major air forces. Another point in the future air combat capability debate is the status of the human being 'in the loop'. However, irrespective of whether it is inhabited or not, there are some fundamental considerations that would impact on the design and production of the sixth generation platform.

There are two basic questions that must be answered in order to fathom the possible direction of development that could take place. First, whether the sixth generation platform would be a quantum leap in capability or be an evolutionary move towards an interim level of improved technology that would permit continuous improvement of capabilities. The F-22, which is the epitome of a fifth generation combat aircraft, took 20 years from conceptualisation to initial operating capability. The second question flows from this: if the decision to proceed with the development of a sixth generation air combat capability is delayed, will industry be able to maintain the level of know-how necessary to design and produce a technology-intensive airborne platform at a later stage?

Steering clear of the financial debate that would follow a sixth generation air combat capability development program is simply not possible. The highest concern—especially for partner nations—in the entire F-35 Lightning II Joint Strike Fighter (JSF) program has been its cost overruns. It can therefore be reasonably assumed that the sixth generation platform would be developed with life cycle costs being a critical consideration in its design and development philosophy. This in turn could translate to processes that would lower sustainment costs, composite manufacturing techniques that would reduce costs in the long term, and affordable tooling for manufacture and maintenance. In any effort to keep costs within affordable limits, numbers count. There will be a concerted attempt by the manufacturers to involve as many partners as possible in the design, development and manufacturing processes to ensure that large numbers of the platform are procured, much more than the current state in the JSF production.

Further, the need to have a large production number that would mitigate the financial risk will necessitate a safe and steady approach to capability development, negating the acceptance of any 'leap-ahead' technology. The answer to the first question posed earlier becomes naturally obvious. The sixth generation combat capability will only be a forward projection of the fifth generation, employed in more efficient ways and with the ability to create the necessary effects with lesser dissipation of capability.

If it can be assumed that the sixth generation air combat capability platform will be fielded in the next 25 to 30 years, it will be possible to delineate technologies that would not mature in that timeframe and discount them from being used. First, it is highly unlikely that the science of hypersonics (five times the speed of sound) would have developed to a stage that would make it an operationally viable capability. Second, 'speed of light' weapons would also continue to remain in the realm of concepts and trials. Third, however much the supporters of the concept applaud the developments, autonomous robotic fighters are also unlikely to be available in common usage in the next 30 years.

So what will be the technological and operational changes that would make the sixth generation air combat capability platform different? It is a distinct possibility that a single inhabited platform accompanied by a large number of uninhabited platforms with 'off-board' or 'digital' crew, and designed for specialised roles, operating in concert with each other would be the future of air power missions. These uninhabited 'wing-men' would increase the fighting power of the 'combat package' without any extra effort. The platforms, both inhabited and otherwise, would be far more stealthy than their fifth generation counterparts; have engines that can be fine-tuned in flight to achieve optimised flight performance in both subsonic and supersonic speed regimes; have airframes that could change its shape in flight, morphing to emphasise the parameters that prioritise speed or persistence as required; and have built-in kinetic and cyber-attack capability.

In terms of weapon carriage, Directed Energy Weapons (DEW)—laser and microwave—becoming operational are a distinct possibility that would give airborne platforms the ability to defend against incoming missiles and also to be offensive on their own. The conspicuous advantage of DEW is that they can be regenerated in flight, creating a situation of a platform possessing unlimited ammunition. Development could also take the form of pulse weapons that could scramble the internal systems of an adversary's airborne system, making it operationally ineffective without actually destroying it. Developments in air-to-surface munitions could see the fielding of systems that can be configured in flight to create the necessary proportionate effect, depending on whether degradation or destruction of the target is being sought. This concept of effect-based adaptation of munitions will revolutionise the strike role of air power.

The future platform will function as one large integrated sensor, thereby eliminating the need for the carriage of an airborne radar and simplifying the design and maintenance requirements. At the same time, the use of fibre optics inside the platform will make it resistant to jamming or spoofing of data and improve the level, detail and fidelity of information that is made available to the operator. The platform by itself would be able to collect data from external sources, fuse them, and then advise the pilot on the threat scenario as well as the possible courses of action that could be taken to eliminate it. This advice could also be in terms of whether or not it is necessary to destroy a threat or merely incapacitate it temporarily. Once again, this capability will facilitate the development of a completely different methodology for the application of air power.

Sixth generation air combat capability is on the horizon, and the '75% solution' is unlikely to be the preferred option for air forces looking towards the future. How many of the futuristic technologies will actually transform into tangible capabilities is anybody's guess. However, if past precedence is anything to go by, then it is more than likely that air power is once again on the cusp of far-reaching capability changes.

# Next Generation Unmanned Aerial Vehicles (#223)

**Key Points**

- *UAVs have become a crucial element within the capability-spectrum of most military forces.*
- *UAVs have become technologically more sophisticated and therefore more expensive to acquire, maintain and operate.*
- *The next generation UAVs will need to be stealthy, faster and more flexible for them to be effective systems in contested environments.*

There has been an unprecedented proliferation of Unmanned Aerial Vehicles (UAVs) in the past two decades and a commensurate increase in their employment both in conflict and non-conflict situations. While the legal and moral aspects of using these vehicles in their armed incarnation are hotly debated topics, the fact that they have become ubiquitous within the air power construct is fully accepted by all. However, UAVs continue to have their detractors and doubters although their usefulness and advantages have been clearly demonstrated in both the Afghanistan and Iraq conflicts. Since the advantages they bring are so much more than the few issues in their employment, they are unlikely to be made redundant by air forces around the world. Therefore, development of UAVs with improved capabilities is being pursued with vigour by a number of design and manufacturing units, with the tacit and often overt support of a number of military forces.

The development of UAVs has reached a critical point, not in terms of technologies that provide ever-expanding capabilities, but in terms of the resource availability to continue the process of cutting-edge development. The decision regarding the future of UAVs will hinge on two interconnected factors. First, the inclination and ability of leading military forces to financially support the research and development; and second, the willingness of the industry to keep pace with the military demands, even when only an outline capability requirement is made available. Industry by itself is unable, or more likely unwilling, to initiate bold and innovative steps to go beyond the proverbial envelope in developing UAVs with quantum improvement in capabilities. Only a well-constructed defence-industry partnership will create UAVs that will change the fundamental conduct of conflicts.

The fundamental change in thinking about UAVs within most military forces is that they are now being considered mission systems as opposed to airborne platforms. Therefore, the question being asked and debated is primarily about the mission that it can perform rather than about the performance of the UAV. This has in turn led to UAVs being loaded with more high technology sensors and systems that diversify their capabilities and provide a broader spectrum of capabilities that can, when required, be narrowed to achieve focused application of the desired capability.

From a military perspective, UAVs have, until now, been employed in benign airspace environments where they have not faced any serious threat to their safety. Secondly, so far they have also not faced any threat from concerted electronic attack. However, Iran claimed that they were able to 'hijack' and down the clandestine, and then cutting-edge, RQ-170 Sentinel in the desert near Afghanistan in December 2011. If this was indeed the case, then a considerable amount of work needs to be done to secure UAVs from such attacks. Further, next generation UAVs will have to embed the capability to operate in contested and high-threat environments.

Any future conflict scenario will most likely be much more demanding in terms of the air environment in relation to that encountered in both Afghanistan and Iraq in recent times. In a crisis, say for example in the South China Sea, the current generation of UAVs would not have much utility and more importantly would not survive for very long. Survivability therefore has already become a key issue in the development of UAVs. This would mean operating at faster speeds and incorporating sophisticated self-protection sensors within the platform. The downside would be that UAVs, that started life as cheap alternatives to manned platforms, would not be 'affordable throwaways' any longer. In fact, the more sophisticated UAVs in operation today cannot be considered cheap by any standards. The balance between cost effectiveness and mission competency is gradually getting skewed.

Another aspect that is engaging design engineers and operators is the need to address the ability of UAVs to self-deploy into theatre. This means that UAVs will have to transit across international airspace within the existing, or slightly modified, airspace control system. Since airspace control is intimately connected to civil and commercial air activities, this may yet prove to be a sticking point in the future development of UAVs. Purely from a military point of view, self-deployment capabilities would be a much-desired step-change in UAV operating concepts. It would provide the force with a capability that does not leave any footprint in hostile or even friendly neighbouring countries. The concept of 'global reach' would take on a different meaning.

There is no doubt that UAVs have become the preferred systems to acquire intelligence, surveillance, and reconnaissance from the air. In the near-term future UAVs will grow into the realm of electronic warfare (EW) with immense consequences for the way in which the first day of war operations are conducted. There has been a great deal of discussion regarding UAVs being highly suitable for the 'dull and dirty' missions. The dirty in this context are highly necessary (but also highly dangerous) missions like suppression of enemy air defences at the commencement of any operation. The combination of EW and strike capabilities embedded in the same platform would make it a formidable system that could achieve mission objectives with a substantially higher probability of success than even with the most sophisticated systems that are available today.

UAVs already possess highly efficient strike capabilities and the next generation vehicles will gradually incorporate the ability to interoperate with manned aircraft in combined operations. From the segregated environments in which these two operate, the next generation UAVs will be able to function in a more integrated and synergised manner with their manned counterparts.

The emphasis for UAV development so far has been endurance. However, future systems would need to be able to transit rapidly to and through an area of operation, necessitating the integration of larger and more powerful engines. This will also underpin its ability to undertake combined missions with faster manned aircraft and systems. Another aspect that is considered both a boon and a bane is the issue of autonomy. Improvements in this area are definitely in the pipeline, but at least at present there is very little appetite for handing over significantly more responsibility for mission control to the system itself.

The imperatives for the next generation UAVs are clear: they need to be stealthy with high performance engines and advanced payloads; they require a quantum change in computing and communications capabilities to ensure on-board processing; and, they need to retain the flexibility to change the payload as required in an operating environment.

# Manned or Unmanned? The Future of Air Power Delivery (#237)

> **Key Points**
>
> - *Unmanned systems have become extremely capable in the past decades and currently can also deliver lethal strikes*
> - *They also have few inherent disadvantages—slow speed, lack of self-protection—that make them vulnerable when operating in contested airspaces*
> - *It is highly likely that a composite formation composed of more unmanned systems, controlled directly by manned fighter aircraft will be the future air power delivery pattern*

A recent news article stated that small unmanned surveillance systems such as the Gray Eagle and Shadow—increasingly popular with soldiers for the reconnaissance and surveillance capabilities they bring to the battlefield—have been used in a series of teaming tests with the manned Apache AH-64 E model, the latest in the US Army's arsenal. The tests were successful, taking the two unmanned systems into the realm of true interoperability between multiple aviation systems.

Unmanned aircraft systems have been transmitting surveillance videos to pilots through a ground station control system since about 2006 and these tests demonstrated a quantum leap in interoperability by permitting the helicopter pilots to not only receive the gathered information directly, but also to be able to transmit command and control guidance to the unmanned system.

Although the control of unmanned systems from the cockpit of a manned platform has been considered a possibility for some time, it is only now that scientists have been able to deliver the first steps in this direction. However, this breakthrough poses an important question regarding the future of air power delivery—whether it is going to be with manned or unmanned airborne platforms or a combination of the two.

There is no doubt that the manner in which technology is shaping the application of air power has maintained a blistering pace in the past few decades. The unmanned platform was in its infancy just two decades ago and now it is on the cusp of being able to deliver weapons in a semi-autonomous manner. The delay in creating an autonomous weapon delivery system is not so much that of technology as that of the reluctance of human beings to accept a completely independent, weapon yielding airborne platform. Having said that it is important to acknowledge the moral and ethical issues that such a system brings to the debate regarding the employment of these systems.

Stemming from this nascent development is the possibility of unmanned systems being used in the delivery of more air power roles. Conceptually there is already the understanding that unmanned systems could be employed in the 'first-day-of-the-war' missions that are considered to be more dangerous than ones that follow as the conflict progresses. By using unmanned systems in the suppression of enemy air defences (SEAD) and other high-risk missions the chances of having own casualties is reduced, which is a fundamental consideration in all mission planning.

The concept is now being broadened to investigate the use of unmanned systems for more missions. While the capability does exist for these systems to perform a broader spectrum of air power missions, they also have some limitations. The current unmanned systems suffer from the disadvantages that they are relatively slow; have limited on-board self-protection suits; and are not yet capable of taking autonomous evasive action for their own safety. The fact is that so far they have only been employed in a benign air environment wherein they have not faced any aerial opposition or tangible air defence threat. However, their usefulness and superiority in the intelligence, surveillance and reconnaissance (ISR) role cannot be down-played. It is in this sphere that their interoperability with manned platforms can be enhanced and optimised. The US Army trials are the first steps in this direction.

Optimised employment of air power assets aim to achieve, in a fundamental sense, an appropriate level of control of the air in order for a military force to be able to successfully undertake other tasks. The use of unmanned systems in this role is still limited to SEAD missions and these too still require close monitoring by a manned ground control system. Autonomous SEAD missions are unlikely to be undertaken at least in the medium-term future. Further, in other aspects of achieving control of the air in a contested environment, such as air combat, the unmanned systems have currently no role to play. Autonomous air combat undertaken by unmanned platforms is still a vision and is far from reality. The history of air power is replete with examples of the gap between vision and reality becoming unbridgeable in the near-term.

In the strike role, unmanned systems have proven their credentials, even though the airspace in which they have operated so far has been uncontested. It is also true that in a contested air environment the chances of survival for the current fleet of unmanned systems are minimal. Similarly, even in the ISR role, these systems will not survive dedicated opposition and capable air defences. This primary drawback diminishes the potential impact of unmanned systems in the conduct of even semi-conventional conflicts. Here lies the dichotomy—risking human life should be the last resort and a carefully considered option in military operations; unmanned systems reduce such risk, but their own ability to achieve the desired operational and tactical objectives in a contested airspace is minimal.

Conceptual developments in optimising the application of air power have tended to focus on this dichotomy for the past few years, especially since unmanned systems have matured into weapon-delivery systems in the strike role. Complete autonomy in weapon release, even in a benign environment, is wrapped in debates regarding ethics, morality and political correctness. Therefore, the current conceptual thinking is leaning towards the control of unmanned systems by a manned platform that could stay outside the lethal range of enemy air defences and other weapon systems but act as a command and control centre for unmanned systems to operate within the lethal envelope.

A futuristic scenario that is being painted often in recent discussions is of a 'mother' fighter aircraft that has the ability to control a number of unmanned armed systems that range far ahead of the mother craft and which can be individually tailored to attack and neutralise both airborne and ground targets. This would assume some amount of manoeuvrability to the unmanned systems, which is a factor that scientists are currently hoping to achieve. When, and not if, this comes to pass, which by conservative estimates would be in the decades, the delivery of lethal air power will once again undergo a quantum change.

Predictions of the future are inherently a risky process. However, it can be stated with some assurance that in the not too distant future air power will be delivered by composite formations consisting of more unmanned systems, controlled by a few manned aircraft with enhanced combat capabilities but being employed principally as command and control nodes. Their combat capabilities will be very seldom brought to bear. A purely unmanned force is highly unlikely to take to the air and all capable and modern air forces will resort to an optimum mix of manned and unmanned platforms to enhance the delivery of lethal power through the air. The dilemma for military planners will be the necessity to strike the optimum balance in allocating limited resources to the manned and unmanned systems.

# Uninhabited Combat Aerial Vehicles and Artificial Intelligence (#242)

The discussion regarding the utility of Uninhabited Combat Aerial Vehicles (UCAVs) has been on-going for some years now. Recently, the question of 'Artificial Intelligence' (AI) has been added to the mix and the result is a discussion that has broadened considerably and spans a spectrum from the totally negative to science-fiction scenarios depending on individual opinions. When viewed pragmatically, it is necessary to consider UCAVs and AI independently although they create sophisticated opportunities when employed in a combined manner. From an air power perspective, it is important for all practitioners to understand the intricacies of employing UCAVs and then explore the practicalities of combining this capability with AI.

**Key Points**

- *UCAVs have proven their efficacy in the strike role while operating in a benign airspace*
- *Artificial Intelligence has not yet come of age to be combined with airborne platforms for them to function in a seamless manner*
- *In the long-term future, the Uninhabited-AI combination could prove to be a deadly combination in the application of lethal air power .*

Although the term Unmanned—here the term 'manned' is used in generic sense and denotes a human being rather than the gender of the individual—has been, and continues to be used for UCAVs, in the current context the correct term would be Uninhabited, since there is a human-in-the-loop in terms of the missions that these platforms undertake. More importantly, the decision to launch a weapon is always taken by a person within the decision-making hierarchy of the force employing the UCAV. In other words, weapon-launch is not an autonomous function in these systems. The term autonomous is used to indicate that the platform has complete freedom of operations including weapons launch from the time it is launched till its return to base.

Contemporary UCAVs are 'uninhabited' but completely controlled by human operators at all times. In any case, irrespective of the term unmanned or uninhabited, these vehicles always operate with a controlling human-in-the-loop. In fact, it takes around 150 to 175 people to keep a UCAV in the air. However, the advantages of UCAVs are many, the most important being the fact that one's own airmen are not flying into harm's way in a conflict situation.

Artificial intelligence (AI), is something completely different. It is the intelligence that is inserted into a 'robot' (the term encompasses any machine capable of perambulation on its own, on the surface, below surface, or in the air) so that it functions in an autonomous manner, without any human input during the full span of its cycle of operation. While the combination of Uninhabited and AI could be extremely successful in terms of the machine carrying out mundane and specific jobs, when it comes to using this combination in the application of lethal force, which is what UCAVs do, the situation is altered in a discernible manner. There are a number of factors that inhibit the use of the UCAV-AI combination in combat operations.

First and foremost is the inherent and long-cultivated distrust that human beings as a species have for individualistic machines with a mind of their own. While it took many generations to build this suspicion into the psyche of human beings it will take even longer for the distrust to be gradually converted to belief, which will then be converted to uninhibited employment of AI under all conditions. This change would require concerted education, not only for the decision makers, but also for the lay person who would otherwise question the wisdom of letting machines 'run riot'. A factor that is often overlooked in this intangible space of distrust and belief is the role played by popular cinema and science fiction literature, which have so far produced more scary scenarios regarding the employment of machines with intelligence, than ones that support the optimised employment of UCAVs or other robots.

Second, and stemming from the human element of trust, is the political reluctance to employ fully automated combat vehicles with the freedom to engage the adversary with lethal force when deemed necessary. The background to this reluctance needs some explanation. Over the past three decades or so, collateral damage, while applying lethal military force, has become increasingly unacceptable, both from a political and humanitarian viewpoint. Further, when such damage is caused by the employment of air power, it seems to bring out the most vociferous condemnation on the air force and the nation responsible for it. However, what goes unnoticed in the elaborate press coverage of such incidents is the fact that in all kinds of military operations, even in situations wherein the decision on the spot was made by a human being in a considered fashion, collateral damage can never be avoided with one hundred percent assurance. Even so, a mistake made by a combination of UCAV-AI will never be politically acceptable for all parties concerned—the attackers and the attacked. The end result in this case is that fully autonomous application of air power is unlikely to become a reality in the near to mid-term future.

Third, at the strategic level of command and control of an operation, currently there does not exist the facility to integrate fully autonomous UCAVs into the broader joint campaign structure. The current best case scenario is a conceptual outlook that envisages an inhabited platform—a fighter or an AEW&C aircraft—controlling a number of UCAVs that could be employed as required by the human being in command of the overall force package. Even such a scenario is still far-fetched in terms of its implementation and is a concept that is still being analysed. It will require a great deal more refinement as well as operational and tactical interpretation to be even trialled. A conservative estimate is that fully operationalising such a concept is unlikely to take place within the next decade.

So where does it leave the employment of AI from an air power perspective? Obviously the fundamental advantage of a UCAV-AI combination is the ability to create a 'launch-and-forget' capability for the application of lethal force from the air. Such a vehicle could be programmed to 'hide' when in the surveillance mode and only become 'visible' during the terminal phases of designating and neutralising a target. This situation would be the ultimate in terms of enhancing strike capabilities of air power, especially when engaging a time-sensitive target of fleeting opportunity. Unfortunately there is an operational caveat even to this scenario. This can only happen in a benign airspace, either because there is no opposition or when the opposition has been sanitised through a regular air superiority campaign. Further, such a scenario will not be politically acceptable for a long time to come.

The question of air superiority or control of the air at the necessary level brings in another challenge to the UCAV-AI combination—their employment in air combat and the air superiority campaign. At least for the near to mid-term future it is inconceivable that autonomous UCAV-AI platforms would be permitted to function within the broad spectrum of air superiority missions. The factors that inhibit their free-ranging use have already been enumerated above. In the extremely complex mission profiles that constitute the air superiority campaign, especially in a contested airspace, these vehicles could even be impediments, at least in the current construct and concepts of operations.

Air power has definitely taken the first steps towards employing UCAVs for missions that are considered to be high-risk for the aircrew concerned, which are normally against fixed and immobile ground targets, such as static air defence systems. Further progress will be, of necessity, slow and spasmodic. The futurists who predict an air battlespace where only autonomous airborne uninhabited vehicles will be fighting it out for supremacy are still dealing in science-fiction. Although the public will be fed a litany of science-fiction movies and literature, Air Forces will have to wait for more decades to realise such scenarios, if ever.

# Automated Aircraft Systems: To Crew or not to Crew, That is the Question (#243)

> **Key Points**
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> - *The Airbus A320-100 was the first transport aircraft to fly with fully digitised fly-by-wire control system.*
> - *A number of false ideas regarding the capabilities of automated aircraft systems have been perpetuated through less than optimum understanding of the role of the pilot in modern commercial transport aircraft.*
> - *The biggest impediment to achieving complete automation in aviation, to the exclusion of the pilot from the loop, is the ingrained human perception regarding personal risk, lack of trust in automation and emotive responses to danger.*

At a time when a driverless car has made a journey across the continental United States, a natural progression is to wonder when, and if, the aviation industry will introduce a similar model which eliminates the pilot from the cockpit in favour of fully automated aircraft. While the employment of an automated aircraft is easy to speculate it is far from reality—at least for the time being.

On 22 February 1987, the Airbus A320-100, an aircraft that went on to become one of the most successful commercial aircraft, flew for the first time with a digital fly-by-wire flight control system. At that time, the automated control system seemed to spell the end of crewed commercial and cargo transportation aircraft—the technological marvel of a completely automated aircraft appeared to be within reach. However, when an A320 crashed at an air show in 1988, the aviation industry was forced to take a more detailed look at automated systems. The lessons of the crash resonated across the full spectrum of transport aircraft operations, including in military aviation. Although the computer is a technological marvel, it can and does fail, which in turn could create critical situations for aircraft in flight.

It is interesting that as aviation technology evolves, many people view the elimination of the pilot as the logical and inevitable end point. The same is not the case with any other human activity—like maintenance or air traffic control—that is equally associated with the employment of air power for benign purposes. There are a number of myths regarding cockpit automation, a pervasive notion being that modern commercial aircraft are flown by computers and that pilots are there only to monitor their functioning. This germinates the idea that in some not-so-distant future, pilots will be taken out of the picture altogether. This attitude is intriguing, to say the least.

Automation can be defined as the science of applying automatic control through the use of various control systems to industrial processes, steering and stabilising ships and aircraft, as well as other applications with minimal or reduced human intervention. While the biggest benefit of automation is that it saves on labour costs, it is also used to improve quality, accuracy and precision, achieved through an optimised combination of electronic and computer technologies. It is in the sphere of accuracy and precision that automation is involved in the operation of aircraft systems.

What was the impetus for automation to take such a central role in aviation? Essentially it stemmed from the growing concern regarding pilot error as a primary cause for accidents. Automation was intended to assist the pilot and also to diminish pilot-fatigue, which was identified as one of the major issues that caused accidents due to pilot error. There is no doubt that automation has increased the safety and efficiency of air operations. However, while automated systems enhance pilots' situational awareness, they have never been alternatives to pilot initiated actions that ensure the safety of the aircraft. The principal task of the pilot is to 'fly' the aircraft and the automated systems assist during extraordinary events, such as emergencies, to free his/her attentional resources to this fundamental task.

In many ways high-tech, automated cockpit equipment that assists the pilot is no different to the high-tech equipment that assists a surgeon or a physician. They vastly improve the capabilities of the human being but are by no means a substitute for the experience and skills required to perform at the level required to ensure safety of the passengers or patients. These systems have not even come remotely close to rendering the pilot (or the surgeon) redundant.

Auto-pilot is a term that is very commonly used to indicate the aircraft being flown in an autonomous mode. What is lost in 'translation' is that automation is only a tool that still needs a pilot to tell it what, how, and when to carry out a function. A combination of several systems that control speed, thrust, navigation, and height require regular inputs from the crew regarding contextual requirements. In order to fly an aircraft in an 'automated mode' the pilot has to make several inputs and then monitor and update the inputs constantly, it is not as simple as just pressing a button and letting the automated system take over.

A flight—from start of engines, to switching off at the destination—is a dynamic endeavour that is complex, fluid and ever changing; in which decision-making is continuous, constant and critical. During this period the crew make hundreds, if not thousands, of subjective inputs and decisions, to ensure a safe flight undertaken within the requirements of standard procedures. Even with the aid of automation, the standard aircraft cockpit can very rapidly reach the point of task saturation for the crew. The situation becomes exacerbated especially if an in-flight emergency occurs, when the assistance from automated systems may be considerably reduced.

There are two fundamental disadvantages that automation brings to aviation, which have not yet been mitigated. First, unexpected automation behaviour or uncommanded behaviour caused by system failure has the potential to create adverse consequences and flight manoeuvres. If this happens at night or when flying in bad weather, the situation could develop beyond the ability of the pilots to control, leading to disastrous consequences. Second, the failure of the automated system may not be apparent to the pilots and the subsequent warnings that are provided are only indicative of the flight conditions being met at that particular time and not indicative of the remedial measures. Delay in assuming manual control can once again lead to crashes and loss of life.

It is often said that modern automated aircraft are 'easier' to fly than older aircraft. In fact the opposite is true. The operational aspects of modern flying requires a prerequisite volume of erudite knowledge—from an understanding of the on-board systems, navigation equipment, weather information and communications, to name a few—in addition to the skills required to fly an extremely sophisticated aircraft safely. In a holistic manner, no automated system has yet been made that can completely carry out the full spectrum tasks that a modern pilot undertakes. However, technology does exist to create such a system, fairly quickly if necessary. Indeed, some experimental systems have already proven that this is possible.

So what prevents the development and use of automation to the complete exclusion of the pilot from the equation? The answer is simple; a combination of human risk perception, trust or the lack of it, and the proclivity towards emotive responses to personal danger. It is a fact that in situations of danger, human decision-making becomes increasingly emotive as the danger moves closer to the individual. Individually and collectively human beings are not yet ready to accept the perceived dangers involved in an aircraft being flown in a fully automated state while they are passengers onboard. The built-in 'safety system' in the human brain will take generations to accept such a situation.

Today, what exists in the modern cockpit is the finest example of what modern technology can provide to improve flying, making it faster, safer and more reliable than ever before. However, aviation is still a long way from taking the pilot out of the loop in both military and civil transport aircraft operations.

# Uninhabited Aerial Vehicles: Possible Future Developments (#249)

Many nations are involved in on-going operations against terrorists, especially in the Middle-East where the operating environment is complex. The intelligence, surveillance and reconnaissance (ISR) role carried out by Uninhabited Aerial Vehicles (UAVs) has become critical to the success of all military operations and is of great importance in the fight against diffused adversaries that are typical in both counter-terrorism (CT) and the counter-insurgency (COIN) operations. Conventional military forces have capitalised on the UAVs' ubiquitous nature and the increasingly sophisticated information that they provide to plan and execute CT and COIN missions.

**Key Points**

- *UAVs provide critical ISR capabilities to military forces engaged in CT and COIN operations.*
- *Technological developments are likely to enhance the capabilities of the UAVs through the provision of improved and flexible payloads.*
- *The utility of UAVs in contested air spaces will be limited because of their survival limitations in such an environment.*

Although UAVs have reached a high level of technological sophistication, large investments are continuing to be made into the uninhabited aerial programs, collectively termed Uninhabited Aerial Systems. A majority of modern air forces today have an uninhabited element resident within them, the differences being only in the size of the force and whether or not they are armed. While UAVs have been on the inventory of air forces for some time, some have also kept pace with force structure changes, creating force elements that can operate independently or in conjunction with manned force elements on an as required basis. Currently most concepts of operations are oriented towards UAVs functioning in support of manned platforms. However, concepts that question this 'normality', where the support comes from manned platforms, and UAVs are the supported element, are already being discussed. This technology is already reflected in extant capability.

There are two points that must be clarified: one, complex missions that require a high level of assurance of success and security will continue to be conducted by manned platforms, and two, UAVs will never completely replace manned fighters, which continue to provide an unmatched multi-role function. This is accepted wisdom within the war-fighting, strategic and technological communities.

In the contemporary operating environment, UAV missions are centred on ISR and, in the case of armed UAVs, time-sensitive strike. In a benign air environment, UAVs provide significant advantages over manned platforms carrying out the same mission—they have greater endurance, have relatively lower operating costs, and when flown at height can be unobtrusive, both in terms of low radar signature and visual detection. Perhaps the greatest advantage is that the more advanced UAVs have great versatility because they can be upgraded with a range of mission-specific systems making them tailored to fit a single purpose mission if required. In the ISR role, advanced UAVs now have the capability to identify and track a single individual for long periods of time. This facilitates the unerring neutralisation of high-value leadership targets when necessary.

It is a sign of the maturity of UAV operations that the capability is now clearly divided into the armed and unarmed versions and the concepts of operations have also diverged accordingly. Even unarmed UAVs have evolved in the mission-set range and are now routinely used in the information, surveillance, target acquisition, and reconnaissance (ISTAR) role, which could be considered an enhanced version of the ISR role. Further, small-sized UAVs have been developed and deployed to detect and track an adversary's mobile weapon systems, a capability that is advantageous in countering diffused adversaries functioning amongst the population in urban areas. These compact UAVs are irreplaceable when it comes to providing land forces with the ability to 'look over the hill.' The Israeli Defence Force (IDF) is reported to have used such UAVs extensively during 'Operation Protective Edge' in the Gaza in 2014.

What is the likely direction of future developments in UAV technology? Possible future developments can be analysed in two independent streams—platforms and payload.

The emphasis on platform development will be to meet the demand for bigger platforms. Air forces want UAVs to be able to have greater range and endurance as well as to carry larger payloads in order to accommodate more capable sensors. It is likely that over the next decade, relatively larger UAVs will be fielded by a number of air forces. The other side of the equation, and one being pursued with equal intensity, is the attempt at reducing the size of UAVs. These would be difficult to detect or capture, but would have extremely limited capabilities since they would only carry a minimum payload.

UAV airframes have not changed substantially in the past few years, although more robust and larger platforms can be expected to be operational within the next decade. The optimisation and miniaturisation of payloads is a key area of research and development in UAV technology. The main challenge for military forces today is finding targets in a short time span, which is all that is available to a deployed force. Further, contemporary targets are less detectable and often widely dispersed. The need to detect them has led to the development of cameras with very high resolution and sensors able to gather wider information. Improved concepts of operations such as fusing data collected by different sources, almost in real-time by live transmissions to a larger platform with greater processing, exploitation and dissemination capabilities are also being trialled. The maturing of this concept could see the integration of airborne early warning (AEW) and signals intelligence capabilities, maybe even on board a UAV.

Electronic Warfare (EW) is another major role in which UAVs are being increasingly employed and the size and weight of the EW payload necessary to provide the required capability is one of the major factors pushing the increasing size of the platforms. Exploratory research is also being conducted in the development of a universal multi-sensor and multi-mission payload that could be carried in both high-altitude long-endurance (HALE) and medium-altitude long-endurance (MALE) UAVs, in addition to manned platforms as well as aerostats. The advantages in terms of cost-effectiveness and flexibility of such a payload would be enormous. This universal payload will provide high-definition infra-red imagers, TV cameras, low-light camera, narrow-field-of-view shortwave infra-red camera, laser range finder and designator.

This Pathfinder has only provided an overview of the advances being made in unarmed UAVs and their payloads. Similar improvements are being actively considered in the armed versions of UAVs.

The importance of UAVs in the contemporary battlefield cannot be overemphasised. However, the greater demands being placed on UAVs will increase the complexity of the system with a commensurate cost escalation as a penalty. Further, air power practitioners must also be cognisant of their vulnerabilities if they are to operate in contested air space. Essentially, in CT and COIN campaigns where significant air opposition is highly unlikely, UAVs perform critical roles in an effective manner. They are not a panacea for the dangers that face the military forces in the efficient application of force.

# Lighter-Than-Air and Hybrid Airships (#225)

> **Key Points**
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> - *The ability to take off vertically and lift heavy payloads are unique capabilities of LTA airships.*
> - *The use of stratospheric airships as cost effective pseudo-satellites is an area where research and development is currently concentrating.*
> - *Hybrid airships that combine their natural buoyancy and aerodynamic lift to stay aloft have particular application in the air mobility role.*

Contrary to the views expressed by Rear Admiral Melville, lighter-than-air (LTA) and hybrid airships have continued to be part of aviation even after a hundred years. In the field of aircraft design, the need for cost-effectiveness and increased persistence are becoming crucial drivers, leading to increased development pressures for LTA and hybrid airships. Their combination of heavy lift and vertical/short take-off and landing (V/STOL) capabilities is an attractive attribute for air mobility operations; while in the intelligence, surveillance and reconnaissance (ISR) role, the enhanced endurance of LTA platforms offer the prospect of providing geo-stationary, pseudo-satellite capabilities.

The use of stratospheric airships as pseudo-satellites was explored in a series of workshops in the US during 2013, with participants from NASA, academia and industry. The aim of this study was to explore the benefits of such high-altitude airships for scientific purposes. It was found that these airship concepts have considerable potential for cost-effective applications for earth and atmospheric sciences as well as for space observation platforms. Such long-endurance, high-altitude platforms would enable atmospheric measurements for monitoring carbon emissions and air quality over mega-cities with far less atmospheric distortion than ground-based sensors. For such applications, airships offer the additional benefit that they would enable much easier upgrades of instrumentation and communication systems than would be the case for satellites. It was recognised, however, that these concepts are currently technologically immature, and a prize-driven challenge was recommended to spur the development of affordable high-altitude airships for these scientific purposes. The first challenge concept recommended was a million-dollar-class prize for demonstrating a 20kg scientific payload being maintained at 20km (65kft) stationary for 20hrs. It was also noted that the US Defence Operationally Responsive Space (ORS) Office may be willing to invest in these capabilities should they be demonstrated to be technically viable.

The potential for more efficient use of energy is a fundamental consideration in the growing interest in airships, especially in the ISR role. Global energy challenges are leading to airship concepts that evaluate the use of renewable energy. For example, a tethered aerostat is currently being tested to carry wind turbines aloft that could exploit winds at altitude for power generation. They are also being evaluated for use in capturing solar power generated energy beamed from satellites in a two-stage transmission process for use on the ground. These concepts are expected to assist further developments in airship applications in the ISR role where long-endurance and energy efficiency are coveted characteristics. A July 2012 patent describes a system for the use of airships in commercial communication relays, which is claimed to have significant economic benefit in comparison to satellites.

Employment in any of these roles would require the generation of power to run the onboard systems as well as to manoeuvre the airship. Given the large surface area of airships, the use of photovoltaic cells is being considered both for power generation and also to create hydrogen for use in fuel cells to power the airship at night. This development also provides options for the onboard production of hydrogen to replenish the lifting gas within the airship. Two recent patents have described multi-ship concepts to increase the persistence of airships. One involves the use of a 'logistics' airship to replenish the power and other requirements of an on-station platform. The other has two tethered airships with an altitude difference of around 5km between them with the shear layer arising from the wind speed difference between the altitudes being exploited to generate onboard power and assist station keeping.

Hybrid airships that combine their natural buoyancy and aerodynamic lift to stay aloft have particular application in the air mobility role. A 2011 Masters thesis from the Canadian Forces College, released to the public only recently, considers the feasibility of employing such a hybrid airship to carry a payload of 200 tonnes in the strategic airlift role. The conclusion of the research is that if hybrid airships are developed beyond the current prototype stage, they could become a niche capability between sealift and traditional strategic airlift capabilities. Further, a US Naval Postgraduate School report found the use of airships to be particularly viable for time-critical shipment of payloads up to 2500 short tons.

Recent patents indicate that there is a wide range of potential hybrid airship concepts being developed. One that is particularly innovative is the concept where a UAV that takes off in a conventional aircraft mode and configuration releases helium or hydrogen into an envelope to provide it with sufficient buoyancy to enhance its on-station endurance. Significant research and innovation is being undertaken in the configuration design of hybrid airships.

Another area where concerted attempts at innovation are being carried out is in the design of the controls where dynamic modelling of unconventional airships and their control is being developed. It is expected that the development of equations of motion will assist with the efficient design of control laws for these platforms. Contemporary literature provides information on the direction of research. Two recent publications examining the development of control laws for airships point towards the employment of fuzzy logic-based methods—one using visual sensor data and the second using ultra-sonic sensors. The processes described in these two papers have the potential to be employed in hybrid and LTA vehicles when they are used amongst buildings. The potential for use in the urban environment for ISR is considerable.

As with all futuristic developments, fiscal constraint will be a limiting factor in hybrid airships achieving their full potential. An example is the US Army's Long Endurance Multi-Intelligence Vehicle (LEMV), which undertook its maiden flight in August 2012. It was estimated by the US Government Accountability Office that the Department of Defense had spent USD 7 billion on 15 different airship programs between 2007 and 2012. The report also concluded that the programs were not sufficiently co-ordinated, that they had experienced considerable cost and schedule overruns, and that there were significant technical challenges to be overcome. It has been recently reported that the LEMV program has been cancelled. In the current global financial circumstances, this could well be the harbinger of even greater constraints on airship developments.

Recently published literature indicates that LTA and hybrid airship concepts are an area of active research interest and limited development activity. Even though their advantages have been clearly enunciated, current economic concerns make it unlikely that any significant developments will take place in the immediate future. It is to be hoped that increased civilian applications for these technologies would drive further developments and that the military will benefit in the ISR and air mobility roles from these initiatives.

# The Combination of Precision, Speed and Reach: A Unique Air Power Capability (#221)

The ability to neutralise an adversary's centres of gravity has always been a coveted military capability. To a large extent, power projection is centred on possessing the demonstrated ability to damage, destroy, or neutralise a selected target. Possession of such a capability also underpins the strategies of deterrence and coercion. Around 250 B.C. Sun Tzu, the renowned Chinese warrior philosopher stated that 'to subdue the enemy without fighting is the acme of skill', meaning the ultimate objective of any military strategy is to bend others to one's will without coming to conflict. Deterrence and, if that fails, coercion is at the foundation on which such a strategy is built.

**Key Points**

- *Effective air power is a powerful deterrent capability*
- *The inherent flexibility of air power can transition from a show of force mission to punitive strike rapidly and almost seamlessly*
- *The combination of speed, reach and precision and the effects that this combination can produce is unique to air power*

All military forces rely on deterrence in varying degrees to achieve a desired end-state in terms of national security. However, small and medium sized forces have to be especially careful to tailor their capabilities such that their deterrent stance is clearly and demonstrably visible and achievable. All elements of national power have to be analysed and optimised to achieve the same effect.

Air power is unique in its ability to pursue a deterrent strategy and also in its capacity to transition rapidly to more escalatory strategies of coercion and punishment, if and when required. In fact, air power can achieve this transition within the same mission if so required, since a 'show of force' mission is equally capable of initiating punitive action without even having to change the mission profile. A strike of this nature could deliver a much greater strategic effect than the mere neutralisation of a target. Although this ability to transition is prized, air power can be a much more powerful apparatus when used to selectively project the power and intent of a nation farther, more rapidly and with precision than any other capability. In addition, this can be achieved without the intrusiveness and risk to own forces that accompanies the employment of surface forces to accomplish the same end-state.

The geo-strategic environment is in a continual state of flux across the globe. The military forces of a nation must therefore strategically monitor the changes that are taking place and evolve accordingly, primarily for two reasons. First, to ensure the continued security and sovereignty of the nation; and second, to ensure the long-term ability of the force to preserve national strategic interests beyond state borders. Failure in the first will invariably lead to failure of the second, and subsequent irrelevance. While deterrence is the preferred option to secure a nation and its interests, in some circumstances, physical intervention and the adoption of a strategy of punishment could become essential. Such actions could be necessitated to enforce peace on warring factions or in the pursuit of the concept of 'Responsibility to Protect'. However, the international socio-political environment today does not favour protracted interventions. If actions have to be initiated, the political imperative will be to keep the intervention 'sharp and short' if possible. This is where the efficient application of air power comes in to its own.

Air power has some unique characteristics. It can penetrate deep into hostile territory without leaving any permanent foot-print; it can carry out long-term uninterrupted intelligence, surveillance and reconnaissance (ISR) of a delineated area almost unobtrusively; and perhaps most importantly it can strike rapidly with precision, discrimination and proportionality.

It is the combination of these unique features of air power that makes it the most coveted military capability in the contemporary security scenario. The ability to rapidly strike, and be precise in neutralising the selected target, is a powerful deterrent. However, there is a caveat: the effectiveness of a precision strike capability as a deterrent will be directly proportional to the demonstrated 'will' to use it if required, while also noting the risk of escalation that accompanies precision air strikes. This is a decision that sits at a level above the military command of air power and therefore should not be viewed as an inherent air power weakness.

Long-range precision air strike, bolstered by accurate ISR, is a most potent capability since it can support the implementation of most military strategies. It can also in some circumstances substitute for other forms of power projection. This capability assumes greater importance in a situation where there is scarcity of resources to ensure that military forces have 'full-spectrum' capability available. Whilst air power's precision strike capability is an expensive capability to acquire and maintain, the unique benefits it provides make it a cost-effective option for contributing to military and national security strategies.

When combined optimally with comprehensive ISR and sophisticated command and control arrangements, air power's precision strike capability can effectively sanitise a deceptively large geographical area—over land, sea or in the littoral environment. Further, this can be achieved rapidly and with minimal overt interventional presence.

The concept of long-range air strikes on centres of gravity is not a new innovation. It was articulated before World War II and practised during that War. What has changed is the sophistication that contemporary air power brings in the employment of this concept. Gone are the days of the 'thousand-bomber' raids, where the destruction of selected objectives was achieved through saturation or carpet bombing, since precision was an unattainable quality at that time. Even with such tactics, there are doubts still being expressed regarding the efficacy of the strategic bombing campaign during World War II—conducted with such enormous losses on both sides. The same objectives can today be realised by a sole aircraft delivering a single precision-guided munition that is also calculated to achieve only the desired, proportional effect. In most recent campaigns precision air strikes have preceded any other military manoeuvre.

The assured proportionality and discrimination that air strikes can deliver, made possible through progressive technological advances, makes the combination of speed, reach and precision a unique capability vested in air power. The effects that the application of this formidable capability can create make air power a critical and indispensable part of military power projection.

# Critical Mass and Air Power (#229)

> **Key Points**
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> - *Critical mass is the minimum number of people and amount or level of capability needed to start and/or sustain an operation*
> - *Critical mass is dependent on the envisaged minimum air power requirements needed to effectively enact the articulated strategy of the nation*
> - *The two major factors in determining critical mass are people and capability*

The term 'critical mass' is derived from nuclear physics, where it is defined as the smallest mass of material that can sustain a nuclear reaction at a constant level. Over a period of time the term has found its way into common usage in social dynamics to mean a sufficient number of people adopting a particular social innovation in which the rate of such adoptions become self-sustaining and thereby creates further growth. In this sphere, critical mass is influenced directly by size, interrelations and the level of two-way communications.

The concept of critical mass is not new and it has been used in medicine, specifically in the area of epidemiology, since around 1920 to explain the spread of communicable diseases. However, it gained popular understanding in the 1970s, when game theorist Thomas Schelling and sociologist Mark Granovetter used the term to explain the actions and behaviours of a very wide range of people and activities. The concept or theory of critical mass has thereafter been adapted by businesses and other aspects of human endeavour. Therefore, it is not surprising that military forces also use the concept to understand and underline certain aspects of their organisations.

Taken into the military sphere, the nuance of the definition of critical mass changes to, 'the minimum number of people and amount or level of capability needed to start and/or sustain an operation to achieve a specific result and for a new action to occur.'

Critical mass has particular influence on military forces that are numerically limited and only have the ability to project a finite amount of power. Considering that the fundamental responsibility of a military force is to project power to ensure national security, the concept of critical mass should be carefully analysed by medium and small-sized forces. In the current environment of budgetary constraints, that is forcing most military forces to adopt economies of scale, defining the critical mass necessary to achieve national security objectives becomes an onerous responsibility.

Air power is perhaps the most resource-intensive military capability to acquire and operate effectively and efficiently. The combination of shrinking resource availability on the one hand and increased demands being placed on it on the other, makes air power particularly vulnerable to the phenomena of having to operate at critical mass on a continuous basis. So what is 'critical mass', in air power terms?

From the definition of critical mass, two major factors can be derived—people and capability. Each of these will have sub-sets that need to be understood in order to ensure that an air force operating at critical mass does not fall below it. The result of falling below the critical mass is straightforward to explain. The self-sustaining process, which should see the operation to a successful completion, will no longer function as appropriate and the quantum of air power being generated will gradually reduce to a level wherein it will not be sufficient to meet the requirements of the battle, campaign, and war. In other words, the force will fail to deliver its primary responsibility of ensuring national sovereignty and protecting national interests.

Before determining the critical mass in terms of people and capability, it is necessary to determine the minimum air power requirements needed to effectively enact the articulated strategy of the nation for the envisaged minimum period. From this would flow the critical mass required in terms of people and capability.

The critical mass for people would be a minimum number required to carry out the myriad activities necessary to project air power in all its aspects for the required period of time. Dependent on the minimum time that such air power projection is deemed necessary, the entire process of raising, training and sustaining the necessary number of personnel would have to be worked out. Into this equation attrition—through normal redundancies and enemy action—would have to be injected and taken into account. The final calculation of the minimum number of personnel would have to cater for a number of intangible factors such as the broad base available for recruitment, the national ethos regarding military service, educational base of the nation, and the envisaged nature of the conflict.

Calculating the critical mass in terms of capability is a more exacting process and also more prone to be influenced by external factors, beyond the control of the air force. Here the political aspects of national security as well as alliances come into direct play. Air power is, and has always been, a product of technology. Aerospace technology is neither cheap to obtain nor is it easy to develop and maintain at the cutting edge. Resource-intensiveness is just one factor in the overall picture of the aerospace industry. Since air power is at the high-end of technology, most nations are dependent on friends and allies to develop, maintain and deploy an air force of calibre. The availability of the necessary capability therefore becomes a political factor.

If it is taken for granted that the necessary technology and capability will be made available to the air force, the next step in maintaining it at or above the level of critical mass is dependent on the ability of the workforce to optimise the employment of available capabilities. In this understanding of capabilities, it is necessary to add the development of strategic and operational concepts as an important input. Air forces can no longer be totally reliant on their capability edge with assured critical mass to assume success—capabilities have to be very clearly supported by concepts that also function at a minimum critical mass. Critical mass in the intellectual capacity of the force as a whole therefore becomes an integral part of 'capability'. Therefore, the holistic capability of air power is a complex characteristic to measure. Competent air forces would ensure that the critical mass is determined correctly and that they would then function at a state higher than that. This is a big order even for middle level powers.

There is an intrinsic relationship between critical mass and air power—one that can be ignored by an air force only at its own peril. While creating the critical mass in personnel is a relatively straight-forward process, capability development to critical mass is a constantly evolving process. Technological innovations will continually move the goal posts of critical mass in capability. An air force of calibre would therefore have to constantly evaluate their position vis-à-vis the critical mass necessary to deliver the required air power for the nation. Superior understanding of the strategic imperatives of national security will be the underpinning factor that would create a winning air force, able to operate above critcal mass.

## Sustainability of Air Power (#231)

> **Key Points**
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> - *Sustainability is the ability of the force to continue a given operation indefinitely by replacing the resources that are depleted through usage or adverse enemy action*
> - *Overall force capability, resource availability, and environmental context are the three major factors that affect sustainability*
> - *There is an indelible connection between critical mass and sustainability in air forces.*

All military operational planning is oriented towards achieving laid-down objectives and takes into account the need to be able to sustain operations for the required duration. While not elaborating on how these military objectives are identified, suffice it to state that they pave the way for the nation to achieve the desired end-state in any conflict. Further, this end-state will always be a politically determined outcome since cessation of hostilities will only be successfully effected when the belligerents achieve mutually acceptable political understanding and accommodation of their respective interests.

At the strategic level of military planning, the ability of the force to achieve critical objectives that will in turn lead to the successful culmination of a conflict will be influenced by a number of factors. The four critical factors are—the prevailing political context; alliances, both one's own as well as that of the adversary; capabilities resident in the military forces; and the capacity of the military forces to sustain combat operations at the necessary tempo and intensity for the required period of time. The political aspects of a conflict—context as well as alliances—are almost always beyond the control of the military forces. Resident capabilities are a direct function of a robust capability development process, which is a long term activity that requires a judicious combination of political will and military acumen to be successful. Therefore, it cannot be considered to be fully within the control of the military forces.

However, the fourth factor, sustainability, is one that the military forces can directly influence.

So what is sustainability and what are the elements that influence an air force's ability to sustain operations?

The term sustainability is derived from the Latin *sustinere* (*tenere*- to hold, *sus*-up) and the word sustain can mean 'maintain', 'support' or 'endure'. At the strategic level, sustainability in relation to military operations could be defined as the ability of the force to continue a given operation indefinitely by replacing the resources that are depleted through usage or adverse enemy action with resources of equal or greater value without degrading the operational capability of the force at any stage. In this context the term resources would encompass both human and materiel resources. At the operational and tactical level, sustainment could be explained as the provision of personnel, logistic, and other materiel support required to maintain and/or prolong operations or combat activities until the successful achievement of laid down objectives.

Sustainability is built on three pillars—resource availability; environmental context of operations; and overall force capability. Resource availability is a function that is not fully within the control of, and also not the complete responsibility of, the military forces. Further, the environmental context is mainly an external factor. However, overall force capability, although indirectly a function of resource availability at the highest level, is a factor that can be adapted to suit the emerging situation and is to a large degree within the control of the military forces. It is apparent that a flexible and adaptable overall force capability is crucial to ensure that the military force encompasses the required level of sustainability.

Overall force capability is the sum total of a number of sub-capabilities or systems that are necessary to create the desired effects when military forces are employed. The concept of developing overall capability can itself be further broken down into a number of elements, the major ones being—an appreciation of possible future challenges, appropriate threat analysis, consideration of lead-time requirements for a particular capability to mature, technology availability, and force structure. There are a number of other elements—such as the ability of a military force to recruit and retain 'quality' people; domestic financial considerations; and the prevailing socio-political condition in the nation—that have a contextual and limited influence in the broader aspects of the development of overall force capability.

Sustainability is built on the sufficiency of the overall capability of the military force and cannot be built at short notice. Therefore, it becomes imperative for the national security planning process to clearly lay down the desired sustainability level that the military force must maintain in order to ensure national security. The long lead-time required to operationally field state-of-the-art capabilities functioning at the cutting edge of technology is far more visible in the case of developing air power capabilities, in comparison to the other domains. Therefore, the need to appreciate emerging future challenges and fostering the necessary capabilities takes on added impetus in the case of air forces. Even though the results of analysis done and decisions made today will only affect the sustainability of an air force after a decade or more, paradoxically there is an added immediacy to planning for the necessary sustainability at an early stage. This planning is different to other longer term plans, such as capital equipment purchases.

In the case of air power, the single most important factor that influences sustainability is 'critical mass'. An air force that is functioning at critical mass will find it difficult, if not impossible, to imbed adequate flexibility within the available force and therefore, will always function within a certain constraint. While under predictable circumstances this may not lead to failure, sustainability beyond a minimum timeframe will always be an uphill task, and cannot always be assured. It is clear that in order to have assured flexibility, a critical air power characteristic that ensures that unforeseen contingencies are adequately catered for, air forces will always have to function at a calculated percentage above their critical mass. The optimum application of air power is largely based on the characteristic of flexibility. Foreclosing the option to be flexible, due to functioning at critical mass, will eventually diminish the overall capability of an air force to below optimum level. Such a situation will inevitably lead to long-term failure of an air force.

There is an indelible connection between critical mass and sustainability in air forces. Only forces operating above the critical mass will have the spare capacity available to restore lost capability rapidly and within a stipulated time period in order to ensure that the capability loss does not affect on-going operations. This is relatively easier to achieve if the entire force is not being utilised in a particular operation. However, numerically smaller forces will find sustainability becoming a challenge as soon as the entire force gets deployed or is actively involved in an on-going campaign. Under these circumstances operating at the critical mass is not a viable option.

The calculation of critical mass is a foundational requirement to ensure that the force structure planning of an air force is correct and meets the requirements of the nation. In calculating the critical mass from an air power perspective, the entire air power capabilities resident in the military forces of a nation must be considered. However, critical mass in air power is directly affected by its division along the command and control structure within the individual Services and the joint force. Therefore, a purely academic appraisal of the overall air power capacity of a military force that does not take into account the control divisions of holistic air power capabilities could be misleading in its input to the calculation of critical mass. Since air power is viewed as a single entity in a joint force, 'penny-packaging' it through untenable command and control procedures will invariably lead to an air force becoming unable to sustain operations at the required tempo and intensity even while operating above nominally calculated critical mass.

# Air Power: Underpinning Modern Military Forces (#235)

War can be considered the one constant factor in the evolution of humankind from the earliest cave dwellers to the current iteration of the species, some of whom have become space travellers. This fundamental aspect of the progression of the human race has also defined the development of warfighting capabilities—both offensive and defensive—and the gradual evolution of a dedicated body of people who ensured the protection of their own population through the employment of force. Such bodies, which today we would describe as military forces, have been an integral part and society since the beginning of recorded history. The inane tendency of human beings to inflict pain and suffering on others and covet their material wealth have made it necessary for nascent states to develop and maintain military forces, leading further to the evolution of a plethora of strategies, operational concepts, and tactics to protect their interests.

**Key Points**

- *A military force is an indelible pillar of national power*
- *Air power, normally resident in all three domain-centric Services that combine to form a modern military force, is the one single capability that all other combat capabilities rely on for effectiveness.*
- *Air power underpins the success of modern military forces.*

By the time the first cohesive kingdoms were formed around the Mediterranean Sea, the power of a nation was primarily determined by its military might; its ability to enforce its will over other entities in combination with its ability to protect its citizens. Thereafter, for the next two millennia and beyond, military forces have remained a pillar of national power. The capability resident in a military force has evolved over these years and a contemporary modern military force is a far cry from those that were previously considered efficient, for example the military forces of the ancient Greek city-states.

Military forces were also the foundation on which empires were built. The Roman Empire, undoubtedly the greatest empire of ancient times, was built and thrived on the strength of the unbeatable marching legions that they were able to field. Essentially undefeated land power was the ultimate expression of national might. Over the years, nation-states with credible military forces extended their interest to the high seas with the British Empire, where the sun never set, establishing itself as the preeminent Empire of the time based on its ability to control the seas and hence global trade. This required constant policing of the high seas. While the colonies were subdued and controlled through the use of composite army units built for purpose, it was the Royal Navy that dominated the global seas, showing the flag and coercing recalcitrant states to tow the imperial line laid down in London.

The dawn of the 20th century heralded the arrival of air power as an instrument of war that changed the conduct of war and forever altered these 'older' realities. Although it was only a supporting element in determining the final outcome, World War I demonstrated how the potential of military air power would become a critical capability in future wars. During the interwar years its efficacy in more nuanced aspects of power projection came to be understood and selectively applied. The British Colonial Office, headed by Winston Churchill, made the Royal Air Force responsible for containing the uprisings that were taking place in the newly created administrative divisions on the coast of the Persian Gulf—Mosul, Baghdad and Basrah. In 1921, the RAF carried out what came to be called 'air policing' to bring the volatile native tribesmen under control. The protocol was fairly simple—demands were made of the tribes; if not complied with then, leaflets were dropped to warn them (although most of them could not read); and then attacks were carried out from the air. While the destruction that could be brought to bear was minimal, it worked.

In the aftermath of the 1991 Gulf War, an identical containment strategy was adopted in the same region—the Northern and Southern Watch operations carried out by Allied air power. With the experience of several major conflicts to draw upon, it could be said that the basis of military power had by this time shifted to air power. Today, the power of a nation is still measured in part by its military might. For example the military capabilities of the most powerful nation in the world, the USA, is underpinned by air power. As a corollary, the strength of modern military forces is characterised, to a large extent, by the breadth of its air power capabilities. It underpins the nation's ability to 'reach out and touch' and reinforces the manner in which it keeps the peace and fights its wars.

Air power, normally resident in all three domain-centric Services that combine to form a modern military force, is the one single capability that all other combat capabilities rely on for effectiveness. They are integral to the warfighting capabilities of a modern military force, as cannons were to the 19th century armies and navies, or cavalry to the Alexandrian Army. A naval task force cannot hope to operate unmolested without control of the air, provided either by an integral fleet air arm or by the air force of the nation. The army is also reliant on air power to give it unprecedented mobility and firepower on land, while the Special Forces function best when they are inserted, sustained and extracted by air power.

In an abstract manner it can be stated that today air power can destroy any fixed target on the earth. It can physically eliminate all adversaries and in an extreme example, it has the capacity to destroy an entire nation. This capability also indicates one of its major weaknesses. In the contemporary world, large-scale destruction is not compatible with political correctness and the ideals of proportionality and discrimination. Therefore, if the ultimate objective is victory through coercion and limited punishment, air power is likely to fall short, especially when the adversary is aware of the constraints under which air power is being applied. This situation almost always demands intervention on the ground.

Historically, there are examples of air power achieving the desired end-state without having to resort to a ground war, as its destructive power alone has sufficed. The firebombing and finally the atomic bombing brought Japan down to its knees without a ground invasion; coercive punitive raids in Libya curtailed terrorist activities of the regime; and the US-led NATO air campaign in 1999 made Serbia retreat from Kosovo, which ended almost a decade of civil war. If the objectives are carefully defined in a focused manner and the political will of the nation does not wane, air power will be able to achieve it.

In cases where air power was not able to singularly triumph and realise the desired objective, as was the case of Germany in World War II and the Vietnam War, it can be argued that inadequate equipment in the first case and inordinate political constraints in the second skewed both air campaigns. This argument is perhaps only partially true. The 'will' of a people to resist cannot, even today, be correctly assessed and therefore surgical destruction of centres of gravity may not be sufficient at all times to achieve the laid down objectives. A joint campaign, where all elements play coordinated roles, is the only answer to the challenges that emerging complexities in the conduct of a campaign will invariably bring up.

Irrespective of the Service-centricity of the capability, there is no doubting that air power now underpins the effectiveness of any modern military force—without air power a military force is highly unlikely to prevail on the land, sea or air.

# Long-Range Strike: A Foundation of Power Projection (#251)

> **Key Points**
>
> - *Air power is a critical element and at the vanguard of a nation's power projection capabilities*
> - *Groups with relatively limited air power capabilities are building air defence systems that facilitate the concept of air denial, which in turn creates contested airspaces for operations*
> - *Airborne multi-role platforms with long-range, stand-off, precision capability and increased payload, which are also flexible, survivable and versatile will enable air power to counter the challenges of operating in a contested airspace.*

In the rapidly evolving global security environment, it is becoming increasingly clear that nations will need power projection capabilities to ensure their national security and protect national interests. Purely being able to defend the geographical borders of the nation as the end-state in achieving national security and sovereignty is now insufficient in the broader understanding of what comprises national security. So what is power projection? Broadly, power projection is the ability of a nation to influence another through the projection of all its elements of national power individually or in an appropriate combination. However, in common usage it refers to the deployment and/or employment of military power to ensure and enhance national security.

In strategic military terms, power projection is the ability to deploy and sustain military forces far away from home bases. In a more focused manner, it is the ability to employ lethal and non-lethal military capabilities in order to neutralise the adversary's centres of gravity at long distances, in accordance with national security objectives and imperatives. From an air power perspective, there are two major aspects to military power projection and both have political overtones to them.

First, military power projection is not merely the realm of air power. Military capabilities of all domains contribute to the overall capability to project power. In the contemporary security environment however, the timeliness of the projection of power gets superimposed on the ability to do so. When power projection is required at short notice and in a time-critical manner, air power by virtue of its inherent characteristics of speed, reach and flexibility will be at the vanguard in the initial phases. In this situation air power has the onerous responsibility of being the prime mover and enabler in meeting contingent national power projection requirements. Whether it is air, land, or maritime power projection that is required, when time is of the essence it will be air power that first gathers and deploys the assets essential to project the necessary quantum of power needed to achieve the effects required. Success of such power projection will be underpinned by the political influence that a nation can bring to bear on another nation to host foreign military forces, on occasion for long periods of time.

The second aspect is more within the gamut of the employment of air power and directly attributable to it. It requires the application of lethal and non-lethal air power capabilities to create the required effects in a time-critical manner, most often from great distances. It is in this arena that the long-range strike capability of air power becomes a crucial constituent of military power projection capabilities. The ability to mount long-range strikes, which are part of the spread of a balanced and modern air power capability, provides a greater number of options to the government in times of crisis. Even though more power projection options are available, the employment of air power in this role would be directly dependent on the strength of the political will of the nation to do so. As in all other aspects of power projection, political will and influence have an overarching bearing on the employment of air power.

A corollary to air power's capability to rapidly mount long-range strikes is the asymmetric approach to control of the air that contemporary adversaries with limited air power capabilities have adopted. Instead of control of the air they adopt an approach that is more constrained in time and space, which can be termed 'air denial'. While control of the air is primarily built on the offensive application of air power, air denial is inherently defensive in nature. A force with inadequate air power capabilities can rely on this concept to degrade to a certain degree the offensive air power capabilities of a more powerful adversary. This is achieved by building hardened shelters that will minimise damage of aerial attacks and deploying air defence systems that consist of radars and surface-to-air missiles. The versatility of these air defence systems is based on their mobile nature; especially the missile systems.

Under these conditions, the environment for air operations would become contested. A contested airspace is one in which one's own operations would be questioned or opposed by the adversary's air power. In cases where the concept of air denial is employed, the contested airspace would be made sufficiently lethal through the deployment of sophisticated air defence systems. Such an environment is not conducive to the assured survival of airborne strike platforms. In such an atmosphere, long-range strike capabilities that can avoid entering the lethal envelope of a contested airspace, or do so without being detected, would be a tremendous advantage and a coveted capability.

Another factor that has to be considered regarding operations in a contested airspace is the proliferation of electronic warfare (EW) capabilities. In the recent past, there has been an enormous increase in EW capabilities while the costs to acquire or create and integrate them into a capable system have reduced remarkably. In fact EW has now become commercially available and, perhaps more importantly, very affordable. This situation complicates air operations, particularly those conducted in contested airspaces.

The solution to these challenges is to develop long-range strike capabilities at the highest end of the spectrum of air power capabilities. The cost considerations of developing such capabilities point towards adopting a process that creates an airborne platform which can not only carry out long-range stand-off attacks, but can also have other capabilities embedded within it. In this respect, integrating command and control and EW capabilities into the same platform would boost its multi-role capabilities—integrating sensors and increasing the processing power creates a platform that has a broader role than just being a dedicated strike platform. Resource constraints make this approach the most cost-effective way forward in creating future air power systems. It is envisaged that such a system, while primarily being an offensive power projection capability, could also double as a minimal capacity Airborne Early Warning and Control (AEW&C) platform and also as an EW system.

When such a platform is eventually built and made operational, it would revolutionise the manner in which power projection is achieved. It will also become the asymmetry that more powerful military forces will be able to bring to bear on the contemporary spread of irregular adversaries with limited defensive and no offensive air power capabilities. By fielding such a system the challenge of operating in contested airspaces where the adversary is focusing on the concept of air denial can be negated. Such a platform will not only have long-range, stand-off precision capability with increased payload, but will also be flexible, survivable and versatile. Power projection through the employment of air power capabilities would have opened another chapter.

# Air Power and Collateral Damage: The Debate Continues (#247)

**Key Points**

- *The use of uninhabited combat aerial vehicles (UCAVs) to carry out opportunistic, precise air strikes has increased the effectiveness of air power.*
- *Unintended collateral damage and civilian casualties in the lethal application of military power have become politically unacceptable.*
- *Air forces are altering their concepts and tactics to ensure that air strikes do not create civilian casualties, moving closer to a 'zero'-casualty modus operandi.*

Air forces of western nations have been involved in carrying out airstrikes in the Middle East for more than a decade. Starting from the US-led invasion of Iraq in 2003, air power has been used in myriad ways by the intervening forces, predominantly in the intelligence, surveillance and reconnaissance (ISR) and strike roles. Air forces have also utilised the inherent mobility of air power to position and support ground forces and, more recently, to provide humanitarian assistance to people who have been isolated by insurgent action. The operating air environment has so far been benign with the adversaries possessing only rudimentary air defence capabilities, thereby negating the need to mount a dedicated air superiority campaign.

The use of uninhabited aerial vehicles that carry out the dual roles of ISR and opportunistic aerial strikes have enhanced the effectiveness of air power. This is particularly so for focused attacks on enemy leadership, who are only vulnerable for targeting at fleeting opportunities. While the success of such strikes is undeniable, their impact on the overall insurgency is a matter of intense debate in both academic and operational circles. Another aspect that has been contentious is the question of collateral damage— particularly civilian casualties—that is unavoidable in the application of lethal force when prosecuting a legitimate target.

There are two intangible factors that must be considered in any discussion of collateral damage caused by air strikes. First, there has to be an acceptance that even with the most stringent rules of engagement (ROE), 'zero' collateral damage can never be assured. Second, in modern warfare the application of lethal force from the air is the most effective way to minimise collateral damage. In popular belief, air strikes are considered to be more prone to excessive destruction, perhaps because of the widespread destruction that accompanied the bomber offensive in Europe during World War II in which entire cities were obliterated.

Air power has travelled a long way since then. Modern air power is capable of neutralising even a very small target with precision, discrimination and proportionality. With timely and accurate intelligence, air power can and does carry out strikes with almost no collateral damage. This is a prime reason why air power has become Government's weapon of choice, when punitive action is being contemplated. Technological advances have made air power the most effective mode for the delivery of measured lethal force.

The question of collateral damage however does not end with the assertion that it has been minimised to 'acceptable' levels. A minimum level of unintended collateral damage may be tolerable in state-on-state conflicts in which the antagonists tend to operate within a broad spread of the Law of Armed Conflict (LOAC). This could also be because of the relative ease with which combatants and non-combatants can be differentiated in a conventional conflict. Since the conclusion of the 2003 Gulf War, there has not been a single conventional conflict that has been fought—all wars have been irregular in their modus operandi.

There are two unique features of irregular wars that constrain the uninhibited use of air power. First, the fighting force of the irregular force is difficult to identify from the normal civilian population. Further, the insurgent combatants tend to use this diffusion to their advantage by functioning within the populated areas and being embedded within the general population. Second, while the insurgents do not adhere to any norms regarding LOAC, they are the first ones to complain when regular military forces make genuine mistakes in the application of force. They are also very adept at using social media to highlight any such shortcomings. The question of collateral damage, particularly 'civilian' casualties, falls within this broad ambit.

The political repercussions of unintended civilian casualties, notwithstanding the impossibility of distinguishing irregular combatants and civilians, have become a challenge for air forces to overcome. Recently the US and other coalition air forces have stated that they are aiming for 'zero' civilian casualties in carrying out air strikes against the Islamic State (IS) in Iraq and Syria. Since it is impossible to be absolutely certain regarding the identity of a targeted individual, the coalition air forces have started to refrain from proceeding with the mission if there are chances of even one civilian casualty.

What this constraint means to the prosecution of an effective air campaign is that sudden developments on the ground can often force the cancellation of a strike, which could have been of enormous importance to achieving overall objectives. In the case of the current operations in Iraq and Syria against IS, this further degrades the effectiveness of the air campaign since the coalition is already constrained by not having their own troops on the ground which in turn means that there is no support in terms of 'spotters' on the ground to identify targets. The emphasis on 'zero' casualties has made the air campaign less effectual, with some estimates stating that as much as 75 per cent of combat missions are returning without dropping any weapons.

Avoiding civilian casualties is a desireable, noble and humanitarian concept. However, by not neutralising a legitimate target for fear of civilian casualties in a war zone, especially in the current context of the war against IS, they may be able to continue to commit extreme atrocities. The world at large must be made aware that 'zero'-collateral damage and -casualty campaigns are unachievable in practice and also that this level of accountability is not required under the LOAC. Laws governing the application of lethal force by the military require that all 'reasonable' measure be taken to avoid collateral damage and civilian casualties. However, Coalition air planners are cognisant of the fact that civilian casualties are antithesis to the need to win over the local population in counter-insurgency operations. Accordingly, a very delicate balance is maintained between attempts to neutralise high-value targets and the need to minimise collateral damage and ensure, if possible, zero civilian casualties.

How an air campaign is conducted against an insurgent force that is mixing with the civilian population that it has infiltrated, will have direct and profound influence on the way in which the coalition nations are viewed by the civilian inhabitants of the region. The success of air power in combating irregular forces operating completely outside the norms and laws that govern conventional warfare, will depend on its ability to deliver precise, discriminatory and proportional air attacks while ensuring limited collateral damage and minimal civilian casualties.

# The Relevance of the Concept of Strategic Bombing (#245)

> **Key Points**
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> - *The concept of 'strategic bombing' was a major innovation in the application of air power that was brought about in World War II for a number of reasons.*
> - *Diluting the adversary's war-making potential through air attacks connects directly to the political objectives of a campaign, conflict, or war.*
> - *Strategic bombing/attack as a concept is still valid, although the characteristics and methodology of delivery have changed considerably.*

The term 'bomber' in the above quote could well be replaced by 'fighter' in a contextual manner and it would still hold true. If the latest news reports are true, it would seem that the US Air Force is preparing to spend more than $60 billion on a large stealth aircraft that will eventually replace the existing fleet of strategic bombers, other than the Northrop Grumman B-2 Spirit. Does this indicate that the largest and most formidable air force in the world is on track to build the next and the most expensive strategic bomber? It also brings into focus the relevance of the concept of strategic bombing.

There are a number of factors and issues that must be analysed both independently and in combination to judge whether or not the concept of strategic bombing is still valid for the application of lethal air power in the pursuit of national objectives. At the heart of this analysis is the understanding of what 'strategic bombing' as a term means to the air power professional.

The origin of the term can be traced back to World War II when systematically organised and executed attacks from the air came to be referred as strategic bombing, since the attacks were meant to defeat the enemy and ensure their surrender by destroying their morale as well as their economic and industrial ability to produce and transport materiel to different theatres of war. In total war this would mean that all aspects of the adversary's war-making potential, including human resources engaged in any nation-supporting activity, become legitimate targets for air attacks. In the initial stages of World War II, strategic bombing of continental Europe was also the only means by which the Allies had of taking the war to the home of the enemy since the ground forces were only in contact with the German military deep inside North Africa. The combination of these two factors forced the accelerated pace to develop the concept of strategic bombing as a war-winning strategy.

From this understanding a broad definition can be coined: 'Strategic bombing is the methodology used to diminish or neutralise the enemy's overall war-making capability through sustained attacks on targets that may be located deep inside the adversary-state.' In World War II, such attacks led to the complete destruction of whole cities since the accuracy of bombing was nowhere near what was required to exclusively target the war industries. It is from these indiscriminate (with hind-sight) attacks that the issue of collateral damage evolved, which in turn led to the development of the internationally accepted laws regarding aerial bombardment.

Although not directly connected to the development of international standards regarding the employment of strategic bombing, the use of atomic ordnance against Japan could be considered the ultimate operation within this concept. If the defeat and total surrender of the adversary is the final aim of a war, then the use of catastrophic force is perhaps the surest way to achieve it. However, the employment of nuclear weapons has not occured since its initial use in 1945 and is a subject of a different stream of debate, not germane to this discussion.

When viewed dispassionately the concept of making an enemy surrender, because their war-making capability has been neutralised, is an attractive proposition. The reason for going to war may be political, but the optimum military end-state that facilitates the achievement of further political objectives is the unconditional surrender of the adversary. Therefore, strategic bombing is not an obsolete or dying concept. Then what has changed from World War II to contemporary conflicts when the term seems to be rarely used?

The nature of the employment of air power has remained a constant, it is only the characteristics of the conduct and the methodology that have altered visibly. New terms have arisen to indicate this change—strategic interdiction, strategic attack etc.—but at the core the concept has remained the same; the degradation of the adversary's war-making capability.

The improvements, made possible by advances in technology, in both weapon performance and delivery capabilities of modern fighter platforms, has now made 'strategic strike' the favoured term for the same concept. There are two noticeable differences in the conduct of strategic strike as compared to strategic bombing.

First, is in terms of the platform. Strategic bombers are extremely costly to develop/procure, maintain and operate effectively, and therefore may not be an option available to middle-power air forces. Only the United States and Russia currently maintain a viable strategic bomber fleet. The use of strategic bombers to deliver a few bombs on a target would not stand the test of an honest cost-benefit analysis. On the other hand, the long range of modern 'tactical' fighter aircraft— further enhanced through air-to-air refuelling, multi-mission capabilities and enlarged bomb carrying capacity—makes them ideal mid-range strategic strike platforms. Global reach can off course be achieved only by strategic bombers like the B-2 or the in-development Long Range Strategic Bomber (LRSB). Targets that would have required large formations of strategic bombers to attack with the required assurance of destruction in a World War II scenario can now be attacked and neutralised by a single tactical fighter aircraft carrying precision-guided munitions, while also ensuring that collateral damage is optimally minimised. The cost factor and the demonstrated capability of fighter platforms make the notion of the employment of strategic bombers somewhat obsolete, in most cases.

The second difference is the issue of collateral damage, which has now become politically unacceptable and distasteful. This has led to a paradigm shift in the manner in which lethal air power is employed. This altered perception regarding the infliction of 'unnecessary' destruction has also provided impetus to technological innovations that have produced revolutionary advances in weapons capability and delivery accuracy. There is a clear understanding within political and military decision-making circles that dual-use infrastructure and facilities of an adversary should only be targeted in extreme cases. The overriding principle of the humanitarian application of force is of paramount importance for all responsible nations. With the inadvisability of neutralising dual-use or pure civilian centres of gravity and weighingup the need to neutralise targets which are embedded within civilian population centres, the modus operandi invariably is of using 'smart munitions' delivered from a fast attack jet fighter rather than a large number of bombs from a so-called strategic bomber. The modern jet fighter can deliver the desired kinetic effect with precision, discrimination and proportionality.

The United States Air Force has demonstrated the ability of strategic bombers to drop precision guided-bombs independently on different targets in the same mission. However, the cost-effectiveness of using a strategic bomber to neutralise a target that could have been attacked with equal efficiency by a 'tactical' fighter operating in theatre becomes questionable, especially in middle power air forces operating under stringent resource constraints. It would seem that the days of the 'strategic bomber' as a platform are numbered, while the concept of airborne strategic attack continues to remain of primary importance in prosecuting a military campaign successfully.

# Air Power and the Information Domain (#227)

**Key Points**

- *The availability of accurate and timely information is one of the fundamentals for the effective application of military power.*
- *The velocity of information has increased due to continual advancements in telecommunications, sensors, data storage, and processing power.*
- *Project ZODIAC will be a key element in creating an integrated information environment that supports the decisive application of air power in the future.*

In armed conflict, uncertainty, disorder and disharmony are enduring features, commonly referred to as the fog of war. ADF foundational doctrine argues that the lack of accurate or timely information, lack of situational understanding, information overload and contradictory information, all contribute to the fog of war. It proposes that the degree of uncertainty can be mitigated, to some degree, through a number of activities that include: addressing intelligence and information shortfalls; and improving information and communications technology (ICT) systems and processes.

Of the six domains that form the operating environment, Defence describes the information domain as all information and related infrastructure that may influence operations. It includes the collection and management of information and intelligence, information operations, and public domain information. Exploitation of the information domain facilitates the gaining of situational understanding, an essential prerequisite for success in campaigns and operations. Defence also states that the information domain includes cyberspace and the electromagnetic spectrum.

In his recent article quoted above, Lt Gen (Ret) Deptula observes that there has been an increase in the velocity of information due to continual advancements in telecommunications, sensors, data storage and processing power. As a result, he states that the targeting cycle has evolved from months to weeks to days to minutes, and from multiple, specialised, and separate aircraft assigned to separate commands, to "finding, fixing, and finishing" from one aircraft in minutes.

In an example from Operation *Iraqi Freedom*, a Predator piloted from Nevada by the Air Force successfully spotted and identified a sniper who had pinned down a Marine ground force. The remotely piloted aircraft delivered video of the sniper's location directly to an on-site Marine controller who used it to direct a Navy F/A-18 into the vicinity. The Predator laser-designated the target for the Navy jet's bombs, eliminating the sniper. The entire engagement took less than two minutes. Deptula argues that this synergy of precision and information is something we must strive to achieve routinely.

Lt Gen Deptula also states that the US military is now at a juncture where the velocity of information, advances in stealth and precision-engagement technologies, sensor developments, and other technologies will permit it to build a completely new concept of operations (CONOPS) different to those based on legacy models that simply align segregated land, air, and sea operations. The potential is there to link information-age aerospace capabilities with sea- and land-based means to create an omnipresent defence complex. The central enabling idea is cross-domain synergy, which refers to the complementary, as opposed to merely additive, employment of capabilities in different domains such that each enhances the effectiveness—and compensates for the vulnerabilities—of the others.

The right information delivered to the right place, at the right time and in the right form enhances the effectiveness of Defence capabilities in the maritime, land, air and space domains of the operating environment. The concept of information superiority centres on the elements of the fighting force being interconnected at the tactical and operational levels by a robust network of Communication and Information Systems (CIS) that are capable of presenting and disseminating the data required by that force. Therefore, the acquisition, operation and support of CIS, and the recruitment, training and retention of the skilled people who provide these capabilities, require effective management and coordination.

Air Force has foreseen that the span of CIS is expanding and has initiated a transformation project, Project ZODIAC, to prepare for the demands of the future. Whilst traditionally CIS has resided within the 'ground' environment of air traffic control, air battlespace management and air base communications, new capability acquisitions are delivering air platforms that are incorporating highly technical, leading-edge onboard CIS along with platform specific mission planning and support networks. Coupled with this is a growing demand for and reliance upon ICT infrastructure and enhanced applications to conduct air campaigning, targeting and centralised ISR.

Project ZODIAC has two key aims. Firstly, it will define the critical operational and business information flows within Air Force, the CIS elements which enable them and establish a governance framework which will allow for the proactive management of CIS to ensure resilience, reliability and seamless integration. Secondly, it will review the CIS workforce requirements across Air Force in terms of organisational structure, job categories and skill sets in order to provide a plan to transform the current CIS workforce to the proposed future model.

Air Force has committed to a substantial transition in the coming decade, with new capabilities approved by government to undertake the core air power roles of control of the air, strike, ISR and air mobility. As highlighted in the Deptula article, Air Force will not be able to realise the synergies of the new capabilities if it applies current ways of business in the future environment. Air Force must adapt current concepts, processes, systems and command and control (C2) to take full advantage of the capabilities it is acquiring in order to be successful in future security challenges. The capabilities Air Force have now and will bring into service over the next decade are highly capable in their own right, but will be far more effective if operated as an integrated system.

Air Force is investing resources in people and systems to undertake the processing, exploitation and dissemination of ISR information so that it is put to good use. In order to enable superiority in the battlespace, the barriers that stop the best information from being made available for operations need to be identified and removed. Project ZODIAC will be a key element in creating an information environment that supports the decisive application of air power in the future.

To get best effect from the information domain in the generation of air power, Air Force needs to look at the changing nature of the movement and processing of information that supports decision cycles at all levels. In addition to velocity (as described by Deptula), Air Force needs to consider the importance of information to precision and awareness, as well as the risks, such as security, the challenges associated with volume and relevance, and the obstacles to access. Project ZODIAC is one step forward in harnessing the information domain in the pursuit of generating decisive and superior air power in the future.

# National Security and High-End Air Power Capabilities (#219)

**Key Points**

- *The Air Force operates across a broad spectrum of conflict situations.*
- *Air Forces ensure control of the air and therefore the freedom from attack in the third dimension.*
- *Precision, discrimination, and proportionality are fundamental characteristics of a modern air force.*

In a generic manner it is understood that national security involves the safeguarding of the sovereignty of the nation and protecting national interests. While most nations define national security with built-in nuances that are unique to their circumstances and perceived security needs, the fundamental appreciation remains the same. While national security is built on a number of elements of national power, military force is a crucial element that permits comprehensive integration of these elements to achieve national objectives. Air power, primarily resident in the Air Force of the nation, is an indelible part of the military forces and critical to the success of all military endeavours.

The military forces of a nation, including its air force, are expected to operate across a wide spectrum of conflict that spans multiple operations. These operations start with the almost benign use of military forces to deliver much needed humanitarian assistance and disaster relief, to the other extreme end where they would have to fight and win a war of national survival, if and when necessary. Admittedly, in the contemporary world, the probability of the occurrence of a war of national survival seems minimal, although it can never be categorically ruled out. In these circumstances, military forces have to cater to and be prepared for such an exigency, however remote it may seem, for the force to discharge its duties effectively. This would require the force to possess credible high-end capabilities.

The broad spread of capabilities necessary to cater for the spectrum of conflict is perhaps most clearly evident in the case of air power. Air power's ability to rapidly deliver humanitarian assistance into even contested battle areas is unique and a prized capability in the contemporary world. This is so because democratic governments across the world now subscribe to the theory of the 'responsibility to protect' people who are in danger of being overwhelmed by either natural calamities or man-made disasters. This is only an example of air power's contribution at the lower end of the spectrum and may not always be directly connected to national security.

A fundamental requirement of national security is to ensure freedom from attack—against the State and/or its interests. In this aspect, air power has a number of important roles to play. Freedom from attack can only be achieved by ensuring adequate control of the air. Control of the air is an absolute prerequisite that can only be assured by a competent air force with the necessary capabilities. There is, however, an interim step that needs to be initiated before achieving control of the air through the application of air power—the ability to demonstrate a deterrent capability. Even during times of relative peace, in the air domain the Air Force will have to create a credible deterrent posture in order to ensure that potential adversaries do not attempt to undermine national security through either overt and/or covert actions. This will require the high-end of the capability spectrum to be clearly evident in the operational capabilities of the Air Force. Essentially, from an air power perspective, national security imperatives form an ongoing continuum.

These days it has become common, and perhaps fashionable, to state that all conflicts in the future would be irregular in their conduct, and that the military forces must be tailored to fight similar conflicts to those waged in the recent operations in Afghanistan for over a decade. This philosophy, if it can be called that, is short-sighted and fraught with danger because it is developed without a clear understanding of the fundamental requirements of national security and the orientation required of the nation's Air Force to ensure it. The broad strategies within air power that could be applied towards achieving national security are the strategies of influence and shape, deterrence, coercion and punishment. The use of air power to influence and shape has already been discussed briefly in terms of the rapid provision of humanitarian aid. Deterrence and, if it fails, coercion, cannot be achieved in the air domain without resident high-end capabilities in an air force. Air power's capability to achieve the desired end-state has been demonstrated repeatedly in the past decade in a number of operations. The political circumstances that prevail in much of the world today negates the use of ground forces in enforcing the will of the collective nations—normally through the resolutions of the United Nations—on a recalcitrant nation bent on initiating actions that are inimical to world order. The use of air power in a focused and deliberate manner has therefore become the first choice option of governments. This cannot be achieved without sufficient high-end air power capabilities within the Air Force. National security requirements transcend a narrow outlook that would have air power capabilities developed and focused purely on their application towards the conduct of irregular warfare.

At the highest point of the application of air power is the strategy of punishment that also sits at the extreme end of the spectrum of conflict. Whether in an irregular conflict, as some analysts tend to believe the future of conflict to be, or in a conventional conflict against another national air force, the only way the Air Force can deliver its responsibilities is to have the highest-end capabilities with which it can apply force with precision, discrimination, and proportionality that are fundamental requirements demanded with contemporary norms of the conduct of any air strike. These three requirements are inviolate in the application of force and the rules that govern them. The high-end air power capabilities have transformed these requirements into characteristics of air power—a triumph of sophisticated technology at the highest-end. An air force that does not possess these characteristics will normally be left standing on the sidelines when national security interests are being seriously threatened.

There are two fallacies that are regularly articulated when air power and its contribution to national security is debated. First, that all future wars will be fought against irregular adversaries who will not possess any air power capabilities and therefore high-end air power capabilities are now passé. This thinking does not take into account the broader aspects of national security; suffers from tunnel vision; and is a very biased understanding of air power. Nothing could be farther from the truth. Second, that high-end air power capabilities are far too expensive to acquire, maintain and operate and therefore, lesser capabilities could be substituted and could achieve the same results.

Once again, this is an argument put forward by theorists who do not consider or understand the broader aspects of a whole-of-government approach to national security.

No single domain capability will assure national security. However, an air force without high-end capabilities and operating at the cutting edge of technology with precision, discrimination and proportionality will never be able to fully serve the nation's interests.

# The Continuing Criticality of Air Power to National Security (#240)

**Key Points**

- *With increasingly sophisticated technology being available air power has become capable of proportionate, precise and discriminate application*
- *Contemporary conflicts rely more heavily on air power for their successful prosecution than ever before*
- *Predictions of the demise of air power have been made on incorrect assumptions and a lack of understanding of the requirements of national security.*

In June 1996, the RAAF held a conference in Canberra with invited speakers of international repute to explore the theme of 'New Era Security' and investigate the position of 'the RAAF in the next twenty-five years'. The proceedings of the conference are available at the APDC website: <http://airpower.airforce.gov.au/Publications/list/35/ConferenceProceedings.aspx?page=3>

One of the presenters, a much respected academic, finished his rather provocative paper stating,

*'If present trends persist, thirty years from now most air forces will have dissolved into space commands on the one hand and some form of air cavalry on the other. In between, most major combat aircraft will have disappeared. Like dinosaurs, they will be confined to musea where they will no doubt be admired by gaping crowds. Pilots will have hung their pressure suits in the closet, never to put them on again. An age in military history will be gone. It was glorious while it lasted.'*

In a more recent publication, *A History of Air Warfare*, (John Andreas Olsen (ed), Potomac Books, Inc, Washington D.C., 2010) in a chapter written by him 'The Rise and Fall of Air Power', the professor refers to his 1996 paper and makes the same point that the world is moving towards the 'end of air power' and argues that since all future conflicts will be of the low-intensity kind and irregular in nature, 'there probably is no compelling case for independent air power at all'.

These assertions and the logic behind them, especially when they have been made by a respected academic, need to be analysed in detail and comprehensively repudiated.

First, in the 1996 paper a continuum of logic was put forward to assert that combat air power had seen the end of its day. It was reasoned that the 'sheer expense and complexity' of building and maintaining an air force made it possible only for nation-states to do so. From this flowed the idea that air forces could primarily be employed only against other states and since state-on-state conflicts are highly unlikely to take place in the contemporary scenario, air forces would be redundant. The use of air power against irregular forces with no clear borders was considered to be extremely limited and therefore not worth the resource expenditure required. A similar argument has been put forward in the aforementioned book.

It is apparent, even to a casual observer that since 1996 air power has continued to 'rise'—to an extent that most governments consider it as the force of first-choice when responding to emerging challenges. First, the spectrum of conflict in which air power is employed in ensuring national security has broadened considerably in comparison to even two decades ago. It now encompasses humanitarian aid and disaster relief (HADR) activities at the non-lethal end of the spectrum to waging a war of national survival at the other end. Even when engaged in HADR missions, it may become necessary for the combat element of the force to be involved in protecting the airlift and other assets being employed. In a globalised world, responsible nations need to be able to respond rapidly to evolving crises and air power is the only capability that can deliver within a realistic timeframe. The connection between national security and air power, predominantly vested in air forces, is direct and tangible.

More importantly, what needs to be analysed is air power's contribution to the contemporary wars. First, the argument that air power lacks the ability to avoid collateral damage has been very clearly discredited in the past decade or so. Today air power can and does carry out proportionate, precise and discriminatory attacks that neutralises even small and moving targets without causing any noticeable collateral damage. In fact it is this very capability that makes it the weapon-of-choice for employment against irregular forces operating without readily identifiable centres of gravity. Air power has proven itself, time and again, to be more effective and lethal than the employment of surface forces in irregular warfare.

Second, The Western world has been engaged in conflicts against irregular forces for more than a decade, in places far away from home. The operations have all been expeditionary in nature and even the surface forces are compelled to rely on air power—both airlift and combat air power—for strategic sustainment as well as for efficiency at the operational and tactical level. There is now no concept of operations being developed that does not leverage the multi-dimensional capabilities of air power to ensure success in the battlefield. This is a far cry from the predicted demise of all combat air power.

Third, the application of lethal military force is now under extreme scrutiny and therefore the constraints in terms of impinging on the sovereignty of recipient nations when military interventions are contemplated have become important political considerations. Air power's ability to deliver measured responses, repeatedly and with unparalleled flexibility, while not having to create a semi-permanent footprint in another nation is now a prized capability. No government can ignore the advantages and influence that come with the possession of truly expeditionary air power capabilities delivered by an air force. No other military or national capability can compare favourably with the rapid and effective response that air power provides to a government—in peace and in war.

There are some one-sided arguments that are being made questioning the necessity to have independent air forces. These opinions do not take into account the entire spread of air power deliverables and are more often the product of an incomplete understanding of the contemporary battlespace. Air forces provide the fundamental prerequisite for all other operations to succeed—they deliver control of the air. The arguments to dismantle air forces are more often than not made by Western thinkers. It will be necessary to mention here that this thinking comes from the fact that no multi-national Western surface force has had to operate without air superiority delivered by their air forces, ever since the Korean War more than half-a-century ago. In the span of few generations it is easy to forget, even within a well-informed military force, the extreme discomfort when it has operate under enemy air attacks—one only has to ask the British military members who served in the Falklands War. Ever since air power became a weapon of war, control of the air has been and will continue to be the foremost quest of air forces.

In the contemporary scenario, governments have certain expectations of their military forces. A capable air force bridges the gap between expectations and reality by providing flexible and rapid response options to address emerging and evolving national security challenges. The so-called 'fall' of air power, being predicted since 1996, is not visible even in the far horizon. Arguments stating that air power has outlived its usefulness are not only naïve but also ill-considered vis-à-vis the security of a nation.

# Space: Use, Weaponisation and Legalities (#233)

> **Key Points**
>
> - *Modern air power is fundamentally dependent on space-based assets and capabilities for their optimised employment*
> - *Proliferation of space-related activities has made the Low Earth Orbit area crowded with both viable assets and potentially dangerous debris.*
> - *Since weaponisation of the space domain will most likely take place, air forces will have to prepare the challenges that accompany such a development.*

Defence and non-defence subject matter experts consider assured access to space to be one of the most important future trends that will affect the employment of air power. Space is of paramount importance to air power, which is critically dependent on numerous space-based technologies for its effectiveness in current and future operations. Therefore it is not surprising that both nation-states and commercial enterprises are involved in acquiring and developing space-based capabilities. This development will no doubt generate some interesting questions and debate regarding the legalities and ethics of the use of space in a military sense, while at the same time technological developments in space will continue to be at the forefront of research and development.

Modern air power is fundamentally dependent on the Global Positioning System (GPS), which is used for navigation and timing across a range of systems. There is currently research being conducted to develop a new system, Navigation via Signals of Opportunity (NAVSOP), which uses signals such as radio broadcasts to deduce its position and therefore would be highly resistant to jamming and spoofing. However, it is not clear at the moment whether the NAVSOP could act as a substitute for the timing aspects of the GPS in a space-denied environment. Space is also crucial for communications with satellite communications offering greater agility, flexibility and reliability than land-based networks, although they are also vulnerable to attacks, interceptions and denials.

Since space has been established as a critical element in the application of air power a number of nations have taken up research and developmental activities necessary to possess indigenous space capabilities. Significantly, commercial enterprises have been pursuing the space sector and a number of them now have the capacity to launch and maintain satellites in orbit. The result has been that commercial satellites are available to anyone willing to pay for their services. On the downside, proliferation of space-related activities has made the Low Earth Orbit (LEO) area crowded with both viable assets and potentially dangerous debris. Although the first satellite, 'Sputnik', was only launched in 1957, there are over 2000 satellites currently in orbit. This situation is only going to get worse as an increasing number of satellites are launched. The Inter-Agency Space Debris Coordination Committee is attempting to mitigate the dangers of space debris.

The acceptance that the LEO needs to be cleaned up in turn gives rise to other questions: Whose jurisdiction is space? Is there a need now for an international agreement that nothing will be launched into space without the approval of a clear plan regarding its launch and a viable method of bringing it down at the end of its useful life? If this were to happen, who will then be the approving authority? Is there now a need to establish a 'Space Traffic Control' agency similar to the current global Air Traffic Control system? These are questions at present without clear and unambiguous answers, but ones that need to be addressed by the international community sooner rather than later.

The other aspect is the weaponisation of space, which is likely to take place. The question is what form the weaponisation will take and how such a move will impact global strategic stability and international security. New technologies and strategic concepts that attempt to optimise their effectiveness are currently being developed without sufficiently robust international legislation in place to govern the use of space. This is not to say that there is no legislation in place. There is legislation and a number of treaties that are administered by the United Nations (UN) and/or the International Court of Justice (ICJ). However, a number of nations with varying levels of space capabilities have not signed all the treaties and the legislation, as it exists, has gaps in it.

The major treaties are discussed below:

**The Outer Space Treaty – 1967.** The multilateral *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies* forms the basis for international space law by virtue of it being the first treaty to specifically deal with outer space. It is aspirational and mentions how the exploration of space should 'encourage international cooperation' and states that outer space exploration will 'be the province of mankind'. It does partially address the question of weaponised satellites and prohibits placing into orbit 'objects carrying nuclear weapons or any other kind of weapons of mass destruction'. The treaty also prohibits the shooting down of another State's satellite from the ground. The treaty is vague on various matters such as the use of directed energy weapons (DEW) from space and the intentional creation of space debris that would then damage other satellites. It also leaves large gaps in what can and cannot be done by satellites neutralising ground targets.

**The Liability Convention – 1972.** *The Convention on International Liability for Damage Caused by Space Objects* deals with liability issues between nation states regarding damages caused by space objects. It does not explicitly cover weaponised satellites or their employment in wartime and relies heavily on international law to solve any dispute. Opinions differ regarding its applicability to the damage caused by actions initiated in space.

**The Registration Convention – 1976.** *The Convention on Registration of Objects Launched into Outer Space* requires launching nations to notify the Secretary-General of the UN of their intention to launch any object into space. The objective is to have transparency and permit the creation of a system to identify objects in space and thereby reduce clutter and debris. This Convention is not adhered to even by the signatories, especially in the case of military satellites and therefore, there is no comprehensive record of objects in space orbit.

**The Moon Treaty – 1984**. *The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* extends the UN Charter and International Law to the Moon and other planets etc., with the intention that all activities conducted on the Moon or other bodies will be 'for the benefit of and in the interest of all countries, irrespective of their degree of economic and scientific development'. It also emphasises that the Moon is a demilitarised zone. Significantly the US, Russia and China have not ratified this treaty.

The UN Charter is the basis for almost all these treaties and they are all aimed at the peaceful use of the space domain for the overall benefit of humanity. However, there is an argument that since Article 51 of the UN Charter permits a nation the right to individual or collective self-defence in the case of an armed attack, weaponised satellites in the self-defence role would be allowable.

In the contemporary situation it can be assumed that space will most likely be weaponised and therefore, all nations that field competent air forces as part of their security shield will have to contend with the challenges that accompany such a development. There is no doubt that the space domain requires international collaboration and management to ensure that it remains useful to all humanity.

***Cockpit of a C-130J Hercules*** *(Pathfinder #243)*


***J-UCAS Boeing X-45A UCAV technology demonstrator***
*(Source: NASA/Dryden Flight Research Center/Jim Ross, Pathfinder #223)*

***Sikorsky S.51 helicopters in formation*** *(Pathfinder #226)*


***The Hawker Demon: the most potent bomber of the RAAF in 1935.***
*(Pathfinder #218)*


***Armament Technicians loading a Guided Bomb Unit - 24 onto an F/A-18F Super Hornet.*** *(Pathfinder #229)*


***F/A-18 Super Hornet during air-to-air refuelling with a KC-30A Multi-Role Tanker Transport*** *(Pathfinder #231)*


***LTs E Kenny and E. Sutherland (with mascot) of the No 1 SQN AFC preparing to depart on a strike on Turkish positions during the 3rd Battle of Gaza, November 1917.*** *(Pathfinder #246)*

***Configured for air-ground attack, two RAAF Sabres of No 76 SQN execute a near perfect formation takeoff.*** *(Pathfinder #236)*

# History

*On the one hand it is said that if we are to produce our own military planes in Australia then by the time we have produced enough we will have them out of date…on the other hand that if you don’t produce enough aircraft in Australia we will have no industry and will be deficient in any one of those isolations which may have to be faced in a great war…*

Prime Minister R.G. Menzies, 30 August 1954

# The RAAF's Strike Capability PART I: Developments up to the end of World War II (#218)

> **Key Points**
>
> - *Development of significant capability in order to conduct core air power roles can be protracted and challenging.*
> - *Decisions on force structure and capability can be influenced by external factors that could impact on the overall development of national air power.*
> - *During the era of visual, free-fall bombing, a balanced and flexible strike force required a force structure that comprised light, medium and heavy bombers.*

During World War I, it was considered commonplace to classify bomber aircraft as either 'light' or 'heavy'. Aircraft such as the single engine D.H.9, later to serve in RAAF colours, were deemed light bombers. Its modest weight of 1700kg and bombload of no more than 210kg clearly differentiated it from the heavy bombers of the era, such as the Handley Page 0/400 with a weight of 6360kg and 910kg bombload. As aircraft and engine design improved through the 1920s and 30s, larger aircraft such as the four-engine Tupovlev TB-3 redefined heavy bomber capabilities. By the beginning of World War II, bomber aircraft were being described as light, medium or heavy. These simple terms soon became a means of defining a level of capability for aircraft used in strike roles.

Australia's experience in developing its bomber, or strike, capability from 1921 proved problematic. While there was a sound rationale to pursue the induction of larger aircraft with greater range and payloads, external constraints prevented balanced force development, creating challenges for the RAAF in developing a long-range strike capability.

When Ross and Keith Smith made their epic England to Australia flight in 1919, they arrived in a Vickers Vimy, a 'heavy' bomber of World War I vintage. That aircraft was initially gifted to the Australian Air Corps and later taken on charge by the newly formed Australian Air Force in 1921. Plans were made to acquire an additional aircraft to form a long-range strike capability suited to Australia's large land mass and undefended coastline.

This proposal, however, encountered difficulties. Australia had also been gifted a mixed force of 58 D.H.9 and D.H.9a light bombers by the British Government as part of a larger consignment of aircraft and equipment to form the Air Force. Any additional aircraft the RAAF wanted would have to be purchased at a time when the budget and manpower were both insufficient to operate the aircraft already in Australia. There were also Government, Navy and Army requirements that resulted in the purchase of seaplanes and general-purpose aircraft, none of which could have been considered anything more than a light bomber.

At the outbreak of World War II, the RAAF had still not progressed in developing its strike capabilities in any meaningful way. While it had a growing number of Avro Anson twin-engine light bombers of limited combat use, the RAAF had been unable to purchase any medium or heavy bombers. Despite the approval to purchase the Bristol Beaufort for the RAAF in 1938, British industry was unable to supply the aircraft as the UK's RAF demand was taking up all their manufacturing capacity.

As World War II developed into a global conflict, the RAAF expanded into a much larger and better-equipped force. Aircraft such as the Lockheed Hudson and the Consolidated PBY Catalina were acquired from the USA, and local production of the Beaufort began in August 1941. These aircraft, as well as the Bristol Beaufighter, Douglas Boston and the de Havilland Mosquito that were soon to follow, demonstrated to the RAAF the utility of light to medium bomber aircraft. In the trying tropical conditions of the South West Pacific Area (SWPA) of operations in which they were employed, the RAAF's strike platforms were able to operate from austere airfields and conduct wide-ranging operations, which included low level maritime and land strike missions, medium level bombing, close air support and search and surveillance missions.

In common with other nations, the RAAF also found that high performance fighter aircraft could be particularly effective in the ground attack and close air support roles. Australia's Curtis Kittyhawk fighters were progressively modified to carry ever-greater bombloads, finally carrying up to six bombs or an all up load in excess of 680kg. The acceptance of the concept of multirole flexibility would be reflected in later RAAF aircraft acquisitions such as the North American Mustang operated in both World War II and in the Korean War; and later still by the Dassault Mirage and the Boeing F/A-18 series of aircraft.

Australia's experience in the RAF's Bomber Command, in the North African campaign, and with the long-range strike missions conducted by the Catalina aircraft in the Pacific, highlighted the need for the RAAF to operate long-range heavy bombers in the SWPA theatre. Without the ability to produce its own heavy bombers, Australia looked to the UK and the USA to supply its needs. Here politics played a hand, with the UK reluctant to release any heavy bombers to Australia in the belief that it would divert RAAF aircrews from the RAF Bomber Command effort in Europe. On the other hand, the US leadership in the Pacific simply didn't want to provide anything that might distract attention away from the achievements of the US forces in theatre. This combined with the UK pressure on the USA to refuse to supply heavy bombers on the basis of the 'beat Germany first' strategy, prevented supply of such aircraft to the RAAF until February 1944, when Consolidated B-24 Liberators began arriving in Australia.

While the B-24s lacked the manoeuvrability, versatility and rough field performance of the light and medium bombers, they could carry 3500kg of bombs and had a radius of action of nearly 2000km. Further, they had the added redundancy of four engines and the self protection measures of up to ten 0.5 calibre machine guns. The B-24's ability to reach out across the SWPA of operations was demonstrated on 27 January 1945, when two RAAF B-24 aircraft destroyed the hydro-electric power stations at Kali Konto in Japanese held Java. Previously out of range of RAAF strike aircraft, the 3700km round trip was made possible by the Liberator's ability to install long-range fuel tanks into its forward bomb bay while still being able to carry a useful ordnance load in the rear bomb bay.

The combination of light, medium and heavy bombers available to the RAAF's First Tactical Air Force in the SWPA in 1945 gave it the flexibility to undertake a multitude of concurrent strike sorties, each tailored to the needs of each mission. However, this period marked the high water point of the RAAF's mixed bomber force of World War II, it being rapidly scaled back in the post war years. By 1955 the RAAF was operating a mixed fleet of Avro Lincoln and English Electric Canberra aircraft in the strike role. While potent and successful aircraft in their own right, the force did not mirror the broad flexibility of the previous wartime capability.

Part II of this Pathfinder will consider these postwar developments of the RAAF's strike force from 1945 to 2003.

# The RAAF's Strike Capability Part II: Development 1945–2014 (#220)

**Key Points**

- *Limited capability in the conduct of air power roles will necessitate the compromise of mission effectiveness across the spectrum of conflict.*
- *Multi-role strike platforms with significant performance characteristics provide the RAAF with the most flexible and potent strike options.*
- *Enabling air power roles can mitigate deficiencies in some aspects of performance shortfall in the core air power roles.*

At the end of World War II the RAAF faced several challenges to its strike capability in the post-war environment. In the later years of the war, the value of deploying a range of light, medium and heavy bomber aircraft proved itself across a diverse range of missions conducted in the South West Pacific Area of operations. However, in post-war Australia, there was a great deal of uncertainty regarding the structure of the peacetime Air Force in the absence of any immediate threats to the nation. Government directives were that in the absence of any imminent threat, all efforts were to be directed towards demobilisation and disposal of surplus equipment. This included the disposal of most of the 5585 aircraft the Air Force had in its inventory at war's end.

The finely balanced strike capability the RAAF had developed during World War II was to be disposed of, with little consideration given to retaining the flexible and potent force that had served Australia so well in the final years of the conflict. Instead, the greatly reduced force of 8025 personnel that emerged in 1948 included a meagre force of just 73 Avro Lincoln heavy bombers, supported by a few legacy aircraft from World War II. From this point to more recent years, the RAAF's strike capability would be represented by a single aircraft type. This 'one type fits all' approach was not without its problems however, and over the years the Air Force has been forced to consider a number of compromise solutions to address shortfalls in mission capability, performance and the creation of the desired effects.

In the case of the Lincoln aircraft, their employment during the Malayan Emergency demonstrated the value of bombers with the range and load capacity to conduct sustained attacks on ground targets. However, it also highlighted the problems associated with using what was essentially World War II-era aircraft and technology on time sensitive targets in close proximity to both friendly forces and civilians. The dead reckoning and long predictable tracks used by the Lincoln crews to ensure accurate bombing in the difficult jungle conditions would not have been possible had there been any form of creditable anti-aircraft fire.

The Lincoln was also destined to be the last dedicated piston engine bomber in Air Force service, and was progressively replaced in RAAF service from 1953 by the English Electric Canberra bomber. Powered by two Rolls-Royce Avon jet engines the Canberra was, at best, a medium bomber. Blessed with a range of over 2000 km, the Canberra had outstanding handling characteristics at both high and low altitudes. It was undeniably a very successful aircraft in Australian service, operating until 1982. However, the Canberra variant operated by the RAAF was already obsolete when it entered Australian service. With World War II-era bombsights, the aircraft was limited to visual daylight attacks and carried no passive or active self-defence measures in an era when air-to-air and surface-to-air guided missiles were becoming operational. This coupled with subsonic speed, meant the RAAF's Canberra aircraft were increasingly vulnerable during operations in their intended mission profiles.

The Canberra bomber was further limited in the amount of ordnance that could be carried internally. The normal bombload of six 450kg bombs could only achieve the desired effect if dropped accurately. However, it was calculated that in a conventional war, the RAAF simply did not have enough aircraft numbers to achieve the desired level of destructive power.

One solution to ameliorate this shortfall was to expand the RAAF's bomber force with the introduction of one of the V-bombers operated by the Royal Air Force. However, this plan was rejected by the Government in 1955 as being too expensive, and carrying too great an operating overhead. The other option was to arm the RAAF Canberra aircraft with tactical nuclear weapons. While the nuclear option was seriously considered, wider economic and geostrategic circumstances militated against it (see *Pathfinder #29*). Instead, the RAAF decided to move Canberra operations away from strategic to tactical strikes—in essence, a compromise forced on the RAAF due to the serious shortcomings of possessing only a limited strike capability.

During 1963 there was a considerable alignment of both political and Defence interests to reinvigorate the intention to replace the Canberra with a more modern aircraft. As was becoming increasing common in Defence acquisitions, the Statement of Requirement for the new aircraft recognised Australia's strategic circumstances in justifying the performance and capability requirements of the new platform. By October of that year the F-111 was announced as the RAAF's next strike platform.

In reality, the F-111 was not due to enter RAAF service until 1970. This prompted plans for the RAAF to operate 24 USAF B-47B Stratojets as an interim measure. However, operating an aircraft of this type was not within the RAAF's capability at the time, and despite three B-47s conducting a lengthy visit to RAAF bases across Australia, all plans to operate the B-47 were dropped. The ongoing delays in delivery of the F-111 resulted in the RAAF operating the F-4E Phantom II (1970-73). With modern weapon systems, multi-role capability and demanding maintenance needs, the Phantom provided the learning curve the RAAF needed before the arrival of the even more advanced F-111s. The F-4 experience also suggested that if the RAAF were to operate a single type for its strike capability, then a flexible multi-role aircraft was essential to balance the force.

In many ways, the F-111 offered the best possible solution to the RAAF's strike requirements; its long range and low-level penetration capability, coupled with advanced weapon systems and significant payload, resulted in a capability that provided both strategic deterrence and tactical flexibility. As upgrades enabled precision attack and maritime strike, the F-111 became arguably the most important strike aircraft the RAAF had ever operated. It did, however, reach the end of its useful life—its non-stealthy radar profile, aging airframe and increasing maintenance overheads eventually bringing its august service to an end in December 2010.

Currently, the RAAF couples the multi-role flexibility of the F/A-18F with the reach and penetration generated by air-to-air refuelling. In combination with the doctrinal principles of precision, dynamic ISR and decision superiority, the RAAF's strike capability is as finely balanced now as it was at the close of World War II. Whereas in the past that balance was achieved through a mix of bomber types, today it is achieved through a system of mutually supporting capabilities which generate a far wider range of effects. Instead of managing operations across multiple aircraft types to match capability to effects, today the RAAF manages seams between capabilities to achieve strategic, operational and tactical outcomes.

# The RAAF's First Experience with Rotary Wing Aircraft (#226)

**Key Points**

- *The RAAF's involvement in rotary wing aircraft dates back to World War II.*
- *While promising, the performance of World War II-era autogyros was disappointing when evaluated against specific operationally based criteria.*
- *The emerging helicopters of the post-war era demonstrated significant potential for use across the Joint environment.*

The first helicopter operated by the RAAF, and in fact the first in the ADF, was the Sikorsky S.51 Dragonfly, so called because of its hovering ability and the buzzing noise from its rotors. The RAAF acquired three of these aircraft in 1947 and a further two in 1951. However, the Dragonfly was not the first experience the RAAF had with rotary wing aircraft. As part of a 1942 initiative, the RAAF evaluated a Cierva C.30A autogyro at Laverton with a view to using similar autogyros for military operations.

The interest in autogyros had much to do with their unique flying properties. While considered by some as the forerunner of the modern helicopter, an autogyro can not hover, but can take-off and land with very minimal ground run. They are able to fly at extremely low speeds and are not subject to the stall characteristics typical of fixed-wing aircraft. In the event of an emergency, the autogyro could freefall down to earth much like a falling sycamore seed. Importantly, at a time of great demand on Australia's limited industrial and military resources, autogyros were considered cheap to construct, easy to store and relatively easy to operate. With these characteristics, autogyros had certain military appeal with potential for reconnaissance, transportation and air drop operations.

Although similar in looks to a helicopter, an autogyro has a freewheeling upper rotor, which acts as an aerofoil to generate lift and requires an engine-driven propeller for forward motion. While some early designs were tested with autogyro-like features, none were very successful until a Spanish engineer, Juan de la Cierva, developed the first practical aircraft in 1923.

After experimenting with various designs, Cierva's C.30A autogyro went into production in 1934 and sold well. The C.30A had three folding rotor blades and a reverse aerofoil section on the port tailplane to counter rotor torque. A 140 hp Genet Major engine gave the C.30A a cruise speed of 150 kph and a range of 460 kms. The C.30A was evaluated by the RAF at their Boscombe Down test facility, and 12 went into RAF service between 1934 and 1945. Flown by No. 529 Squadron, these aircraft were used to calibrate coastal radar stations during the Battle of Britain and thereafter.

Of the 100 built, only four Cierva autogyros were imported into Australia between September 1934 and mid-1935. While one of these aircraft saw RAAF service for trials purposes in 1942, it never received a military serial number. This particular C.30A was purchased by Andrew Thyne Reid, a wealthy businessman, who had learnt to fly autogyros at the Cierva School at Hanworth in England. Built at the A.V. Roe works in Manchester as Avro type 671, it was imported and registered in Australia as VH-USR. It was used by Reid and his wife to fly between Sydney and their property at Yass, and for recreational flying around NSW. Reid offered the aircraft to the Department of Defence during the war.

Thyne Reid's unusual aircraft was believed to have first been used by the RAN to track torpedos during firing tests at Pittwater, but it came into RAAF hands at Laverton in 1942 for evaluation. The first autogyro trials on the Cierva C.30 were to evaluate its suitability for army troop transport and for air dropping supplies to troops in the jungle. *Project Skyward* was intended to develop a 'flying Jeep' or 'fleep' out of cannibalised autogyros (presumably what was left of the other three imports). The intention was to tow the autogyro behind a C-47 Dakota, but flying speed of the Dakota at around 120 knots made the concept unworkable because of autogyro structural problems. Initial tow-tests were carried out behind a large Buick car to allow the civilian test pilot, Ken Frewin, to become accustomed to being towed without the problems of propeller backwash from the Dakota. These initial trials indicated that a range of handling and control problems would need to be resolved before the plan could have any practical application. Subsequently the project was cancelled before the autogyro was tested behind an aircraft.

While still at Laverton, a bad landing in a crosswind resulted in structural damage and the autogyro was sent to Marshall Airways for repairs. In the end, these and other tests proved unsuccessful and the idea of using autogyros to drop supplies or transport troops over the jungle was abandoned. So was the idea of a 'fleep'.

After the war, VH-USR was returned to Reid and although he flew it on several occasions, when Reid died, his widow donated it to the Royal Aero Club at Bankstown. In 1979, it was purchased by the Powerhouse Museum where it now hangs from the ceiling on public display.

Despite disappointing results with the autogyro trials, interest in the potential for rotary wing operations remained strong. In June 1943, the Air Board requested information from the US regarding autogyro and helicopter developments for the previous two years. By July the Army were indicating a requirement for up to 25 helicopters, prompting further enquiries with the US. Any thoughts of an early acquisition soon faded when it was made known by Washington that there may be a delay of nine months after any initial order was made before any helicopters might become available.

Undaunted, the Army and Air Force actively pursued options of local manufacture, but were soon dissuaded by the lack of adequate skilled manufacturing capacity in Australia. Despite the Army continuing to show interest, even their enthusiasm for the project waned, and they scaled back their requirement to a fleet of six Sikorsky Type R.5. helicopters. With the war clearly coming to an end, and with other more pressing requirements, the need for helicopters lost urgency, and the proposal was dropped altogether in October 1945.

In 1946, the Air Board reconsidered and decided to acquire a Sikorsky S.51 for evaluation purposes. The aircraft was delivered in October 1947 and given Serial No. A80-1.

After test pilot Squadron Leader Ken Robertson of the RAAF's Aircraft Research and Development Unit tested the Sikorsky in 1948 and gave it a qualified acceptance, the RAAF ordered four more; and so the RAAF entered the helicopter era. By October 1962, the RAAF had received perhaps the best known helicopter of a generation when the first batch of UH-1B Iroquois arrived. The Iroquois went on to serve the Navy, Army and Air Force in peace and war until finally being retired in 2007.

# The RAAF Rotary Wing Experience: Preparing for War (#228)

> **Key Points**
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> - *The development of the RAAF's rotary wing capability required building up critical mass, organisation and forward planning.*
> - *Preparations for operations must have an element of realistic training and conduct of exercises involving the forces that are to be deployed.*
> - *There is significant onus of responsibility on senior leaders to plan the development of both technical and professional mastery of new capabilities if they are to be optimally employed.*

In the years following World War II the RAAF became increasingly interested in the use of rotary wing aircraft. After assessing the use of autogyros through 1942–3, the RAAF and the Army identified a number of roles and tasks which justified the need to acquire a rotary wing capability for the Australian armed forces. However, before any helicopters could be purchased, the war ended and any sense of urgency in establishing an operational rotary wing capability was lost.

However, the culmination of World War II did not end Australia's interest in the potential of helicopters, and in 1947 the RAAF purchased the first of three Sikorsky S.51 Dragonfly helicopters. While this acquisition marked the beginning of military helicopter flying in Australia, the limited number of airframes procured did not immediately bestow an operational capability. Even the later acquisition of two Bristol Sycamore helicopters during the 1950s was insufficient to establish a truly robust operational helicopter capability.

The RAAF achieved a sustainable and capable helicopter force only with the purchase of 16 UH-1B Iroquois helicopters, which were delivered through 1962–64. The first helicopters were initially allotted to No 9 Squadron, then to No 5 Squadron when it formed in May 1964. The Iroquois or ‘Huey’ helicopters provided the RAAF with a modern and flexible platform with which to perform a variety of tasks. Initially the Iroquois were used for Search and Rescue (SAR), Army support and humanitarian aid.

No 5 Squadron’s formation was prompted by the need to deploy a helicopter force to Malaysia as part of Australia’s commitment to the South East Asian Treaty Organisation. To support this deployment it became necessary for No 9 Squadron to increase its training role while continuing to be responsible for the conduct of domestic SAR, Army support and aid flights. This increased training commitment was justified in view of the strategic national requirements.

Once in Malaysia, No 5 Squadron was soon employed in multinational exercises as well as in ‘Border Operations’. These were flights conducted in direct support of operations against communist terrorists, known as CTs, who were still active along the Malaysian/ Thai border area.

It was in these ‘Border Operations’ that the utility and versatility of the Iroquois became increasingly evident and the RAAF began what was to become the long journey of professional mastery of rotary wing operations. However, as it would find out in 1966, the experience in Malaysia would not be sufficient to create the depth of professionalism necessary to carry out dedicated combat missions.

It became clear in 1965 that Australia was considering increasing its commitment to the war in Vietnam. Under these circumstances the possibility that Iroquois would be part of the expanded commitment became very real. At this point RAAF leadership demonstrated a lack of appreciation of the preparation and commitment needed to support such a deployment. There also existed a mistaken belief that the experience gained in Malaysia was sufficient to prepare crews for any likely employment in Vietnam. As events unfolded it became apparent that the RAAF had in fact learnt very little and needed to enter a steep learning curve. That learning experience was to be shared with the Australian Army, who knew even less about the operational deployment and employment of helicopters, but clearly understood that helicopters would be critical to the conduct of their counterinsurgency operations.

In the lead up to the deployment to Vietnam, it became clear that the RAAF had very few experienced personnel, limited numbers of helicopters and lacked training and logistics support within Australia to sustain simultaneous overseas deployments to both Malaysia and Vietnam. It took a major reorganisation of assets as well as command and control arrangements, including the withdrawal of No 5 Squadron from Malaysia, to establish a sustainable base capable of supporting the envisaged tempo, scope and duration of the extended operational deployment to Vietnam.

Even with that reorganisation there remained deficiencies within No 9 Squadron when they deployed. There was a critical shortage of armour plating protection for both machines and personnel and the helicopters had no door-gun mounts. This lack of preparation was typical across the whole Australian task force. For example, the ammunition shortage within the newly arrived Army task force was so critical that the RAAF airlifted nearly all their own stock of machine gun and small arms ammunition to ensure that their Army brethren were not left exposed.

From this difficult beginning the RAAF rapidly demonstrated a professionalism and increasingly adept ability to operate helicopters in the harsh and demanding conditions of South Vietnam. This growing capability and confidence showed its mettle during a critical phase of the Battle of Long Tan.

When D Company of 6th Battalion was surrounded and battling for their lives against overwhelming numbers they became critically short of ammunition and requested resupply by air. With a dangerously low cloud base and extremely heavy rain reducing visibility to almost zero, the RAAF component commander, GPCAPT Peter Raw, himself a highly experienced and decorated bomber pilot, expressed doubts that the helicopters would be able to conduct the mission. However, the senior and most experienced helicopter pilot on hand, FLTLT Bruce Lane was of the view that the mission was feasible and one that needed to be done. Lane was proved correct in his assessment and the beleaguered D Company was resupplied through airdrops even as their stock of ammunition was down to around 100 rounds.

The disparity of experience across the RAAF rotary wing force was progressively addressed as senior commanders gained more experience with helicopters and the force as a whole matured. The 'raise, train and sustain' arrangements that had been instituted with the reorganisation of rotary wing assets on the eve of the Vietnam deployment was increasingly bolstered with the return to Australia of every rotation of personnel from Vietnam. Consequently, the resulting operational training capability was better placed to prepare air and ground personnel for their forthcoming deployments.

In many ways the RAAF was learning while fighting. A situation not unfamiliar to the experience of the AFC in Middle East and Europe during World War I, No 77 Squadron during their transition from P-51 Mustangs to Meteor jet fighters in midst of the Korean War and the more recent experience of No 5 Flight establishing Heron UAV operations in Afghanistan. While it was not an ideal situation, the fact remains that No 9 Squadron rapidly demonstrated a superior ability to operate in theatre. This ability was recognised by our allies when the much better equipped and experienced US helicopters units sought advice from the RAAF on how to better sustain their own operations in the war.

The next historical Pathfinder will consider the RAAF Vietnam helicopter experience in detail, with a focus on the many successes during the deployment to Vietnam.

# RAAF Helicopter Operations Vietnam 1966-71 (#230)

The history of RAAF rotary wing operations in Vietnam 1966-71 can best be described as one of constant improvement. When No 9 Squadron first deployed into Vietnam in June 1966 the unit had the ability to airlift a maximum complement of 40 troops into or out of a secure landing zone. That was of course only if all of the squadron's eight helicopters were available, the weather was good and all of the aircrew were fit to fly. By the time the unit returned to Australia in 1971, they were comfortably capable of conducting a 'company plus' airlift into, or out of, a contested landing zone while concurrently providing gunship and casualty evacuation support to the operation. This could be achieved in marginal weather conditions, at very short notice and across a range of terrain types.

This significant improvement in operational effectiveness was in fact an outward expression of the growth of the rotary wing capability within the RAAF during this period. Not only did the RAAF develop more effective ways and means to provide troop airlifts and logistics support, but it was able to expand the roles performed by helicopters in theatre to encompass special operations, casualty evacuation (CASEVAC), gunship fire support and information operations.

**Key Points**

- *The RAAF developed its Iroquois capability in Vietnam into a highly proficient and effective battlefield helicopter force.*
- *Battlefield helicopters are not typical of armoured or ground based transports, the capability must be properly managed and tasked to ensure ongoing development and availability.*
- *RAAF Iroquois operations embraced a wide variety of roles during the Vietnam conflict, and the utility and flexibility of the platform demonstrated the great potential helicopters would have in future conflicts.*

One lesson that was evident even before combat flying in Vietnam started was that the very few platforms on strength could not be used in direct combat roles due to the lack of armour plating and the paucity of replacement airframes and, more importantly, the limited numbers of replacement aircrews. It was therefore essential that the RAAF husband its rotary wing resources lest they be destroyed in ill considered operations which would generate unsustainable attrition.

Sustainability was an early problem that had to be overcome. In 1966 there were only two dedicated helicopter squadrons in the RAAF, Nos 5 and 9 Squadron. While No 5 Squadron was responsible for Iroquois operations in Australia, including SAR and support to peacetime operations; air and ground crew conversion to helicopters was its primary activity. This was vital work, for the graduates of the training programs were essential to sustain personnel rotations into South Vietnam.

The training at No 5 Squadron could only provide so much of the skills and experience needed. This was especially applicable in progressing pilots through to aircraft captain status and in achieving currency across the expanding roles on which the Iroquois helicopters were being employed. These were skills and experience that could only be gained on active flying duties. For the RAAF from 1966-1971, this meant deployment to Vietnam with No 9 Squadron.

Given No 9 Squadron's high operational tempo, the difficulties in managing aircrew proficiency progression were considerable. However to its credit the unit was able to not only sustain its tasking in direct and indirect support of Vietnam operations, but developed a robust system of progressing junior aircrew to advanced stages of proficiency. Pilots were steadily progressed in stages to qualify as a Combat Co-pilot then on to Combat Captain, Flight Leader and finally to Mission Leader. Later when the No 9 Squadron Iroquois were modified to enable them to be configured as gunships, the proficiencies of Gunship Co-pilot to Gunship Captain to Gunship Flight Leader were also developed, while the proficiencies required for Mission Leader expanded. Each and every level required the pilot to learn and then demonstrate the skills, knowledge and aptitude needed for that particular proficiency. This development program was integrated with operational tasking, thereby minimising aircraft usage on training flights, thus maintaining high availability for both planned and short notice operational tasking.

The initial deployment to Vietnam was in reality only a minimalist capability. The eight B model Iroquois available to send into theatre had only a limited lift capacity of five equipped troops. In order to meet the Australian Task Force commanders requirements for troop and logistics airlift tasks, it was necessary in enlist the aid of an additional US Army Iroquois and crew for the duty CASEVAC helicopter.

While the RAAF's Iroquois still performed CASEVAC missions, the preference was to use the US Army assigned aircraft as this aircraft was both configured for the role and carried a medical orderly onboard. While this arrangement ensured that a casualty would be receiving medical attention as soon as they were loaded on board the helicopter, it did at times create the illusion that the RAAF was reluctant to perform CASEVACs.

The CASEVAC role was in fact a function No 9 Squadron performed regularly. In the aftermath of the Battle of Long Tan for instance, seven helicopters of No 9 Squadron launched into darkness to bring out the wounded. While a US helicopter went into the landing zone with its landing lights on, illuminating the wounded, unwounded and the armoured personnel carriers (APCs) to any nearby enemy forces, the No 9 Squadron helicopters flew into the small LZ without lights as ordered by the ground commander. It was a risky procedure in the era before NVGs, with only the residual light showing through the APC's hatches as guidance. However all seven helicopters managed to land and take away the most severely wounded soldiers of 'D' Company.

When the RAAF was able to purchase the larger and more powerful H model Iroquois, it was able to increase the size of the detachment in Vietnam to 16 aircraft. This resulted in an ability to carry greater loads over longer distances. The increase in capability meant that from November 1970 the RAAF was able to takeover the role of the duty CASEVAC helicopter for the Australian Task Force on a permanent basis. From June 1966 to May 1971, No 9 Squadron was to perform over 4300 medical evacuations.

The improved performance of the H model Iroquois also meant that the enduring problem of providing fire support on airlift operations could be addressed through the modification of several of these new platforms as gunships. The development of an indigenous gunship capability was a significant game changer. In the past gunship support was provided by whatever US gunships were available, making the development of air-ground tactics, training and procedures (TTPs) extremely difficult. Once No 9 Squadron was able to conduct both the troop lifts and the fire support 'in house', the ability of Australian forces to develop mutually beneficial TTPs became viable. This ability became particularly evident in special operations conducted in support of the many SAS patrols inserted/extracted by the squadron over the course of the war.

Throughout the Vietnam War, No 9 Squadron worked continually to develop new and innovative TTPs and capability to better support ground operations and to meet Australia's broader intent in Vietnam. From the difficult first months of operations, the RAAF's rotary wing capability matured and developed into a highly effective force manned by professional masters of helicopter operations. Rarely numbering more than 16 airframes the unit flew 237 424 sorties over the course of their five year deployment with an average serviceability rate of 84.05 per cent. An outstanding effort by both air and ground crew demonstrating the RAAF's ability to mount and sustain its rotary wing capability in the most extreme of operational environments.

# The Australian Flying Corps: Part I (#246)

To the early settlers of Australia, the continent must have seemed harsh and uninviting. In the years following Federation, it became apparent that with its vast outback and great distances between major cities, Australia was particularly suited to the development of both civil and military aviation.

By the second decade of the 1900s, Australia was well on its way to developing its own path to the skies. The idea of a military flying force was first considered by the Government some years before World War I. In 1911, the Minister for Defence, Senator George Pearce, attended an Imperial Conference in London where a wide range of defence issues including aviation were discussed. The Senator returned convinced that Australia needed to develop an aviation corps for Imperial defence.

With the need for an Australian aviation force now defined, the Government moved ahead with plans to establish a military aviation corps, advertising on 30 December 1911 for two competent aviators and four mechanics to form the corps. Though conditions of service were discouraging, two young aspiring aviators, an English barrister Henry Petre (pronounced Peter), and Eric Harrison, from Castlemaine, accepted appointments as pilots in the new corps. Both were living in the United Kingdom at the time of their appointment and in consequence these two newly appointed officers recruited four aircraft mechanics from applicants living in the UK: Richard Chester,

**Key Points**

- *The early airmen displayed the same values that the RAAF holds in esteem today: respect, excellence, agility, dedication, integrity and teamwork.*
- *Australian military air operations over the Middle East have a long history and have always required innovation and perseverance under difficult circumstances.*
- *Members of the AFC developed their own operational doctrine and created a strong foundation for growth.*

Ted Shorland, Cyril Heath and George Fonteneau. All became members of the Australian Army.

Concurrent with the recruiting process, the selection and purchase of suitable aircraft was also carried out. Initially two B.E.2a biplanes and two Deperdussin Monoplanes where purchased. On Petre's advice, a Bristol Boxkite was also included in the purchase. Meanwhile in Australia, the only Army officer with aviation experience, CAPT Oswald Watt selected a tract of land near the Royal Military College at Duntroon as a suitable location for the soon to be established Australian Flying Corps (AFC) and Central Flying School (CFS). However, on Petre's arrival in Australia he felt that the altitude of Duntroon too high for regular flying and after an extensive search finally selected Point Cook, Victoria as a more suitable location. Point Cook was easily accessible by sea and close to Army Headquarters in Melbourne. Accordingly a tract of wind swept grazing land was purchased as the birth place of the Australian Flying Corps.

With war in Europe on the horizon, tents were erected as hangars on the plains of Point Cook and test flights commenced in March 1914. The first training courses at CFS commenced in August with four trainee pilots and six trainee mechanics inducted into the school. The pilot trainees were Captain Thomas White, and Lieutenants George Merz, David Manwell, and Richard Williams, the mechanics were Leslie Carter, Norman Dyer, George Mackinolty, Reginald Mason, Hugh McIntosh and Arthur Murphy.

Lieutenant Manwell was the first student to fly solo in the AFC. Upon landing, another student, Richard Williams took over the aircraft for his first solo flight. Williams would later be was the first to qualify for the award of wings. All students graduated successfully, both earning and paying for their winged brevets.

At the onset of World War I, Australia pledged to help Britain but the Government resisted British attempts to absorb AFC members into the Royal Flying Corps (RFC). The Government preferred to operate and maintain their own squadrons using Australian personnel and thus retain a clear Australian identity for the war effort.

The first wartime mission for the AFC was to assist with the campaign in late 1914 to capture the German colonies and naval fleet facilities based in New Guinea. Lieutenants Harrison and Merz along with four technical airmen—Sergeant Shorland, and Corporals Mason, Carter and Pivot—were sent to provide air support for the Australian Naval and Military Expeditionary Force. However, before the ship carrying the airmen and aircraft arrived, a successful landing had already taken place and resistance across the wider area had dissolved. Consequently, the airmen returned home with the two aircraft still in their crates.

In February 1915 a second opportunity to deploy the AFC arose when Australia answered a request from the Viceroy of India to send trained aviators, mechanics and flying machines to support the British army's push into Mesopotamia (now modern Iraq). The aim was to capture Baghdad and force a Turkish retreat from the region. Australia responded with an offer of air and ground crews but could not supply aircraft. Thus, with Captain Petre in command, the AFC 'Half Flight' of four officer pilots and 41 other ranks, embarked on a new mission.

The first mission of the 'Half Flight' on 31 May 1915 was really the beginning of Australian military air operations. Equipped with what were intended to be 'modern' RFC aircraft but which were actually obsolescent Caudron C.IIIs, the men fought with great courage but suffered grimly. Casualties, capture and illness all took their toll. On 30 July 1915, the 'Half Flight' experienced the first death in the AFC, when Lieutenant George Merz was killed in action along with New Zealander, Lieutenant William Burn. They were the first Anzac aviators killed in action.

As the war effort expanded across the Middle East, Australia's commitment to provide more aerial forces required the formation of a full-fledged squadron. No 1 Squadron was formed at Point Cook, on 5 January 1916, with trained pilots, observers and technical airmen. Lieutenant Colonel Edgar Reynolds led the squadron of 28 officers and 195 other ranks to Egypt and eventually, into Palestine. Reynolds departed for London soon after the Squadron arrived in Suez and another Australian from the Royal Flying Corps (RFC), Major Foster Rutledge, took command. At the same time as arriving in Egypt, No 1 Squadron was allocated an RFC squadron designation 'No 67 (Australian) SQN Royal Flying Corps', in response to a War

Department decree that AFC units would be inducted into the RFC's organisation of squadrons.

As World War I intensified, the importance of air power as a weapon of war became evident. Initially restricted to reconnaissance and observation, the Australian operations soon embraced air-to-air combat. Fighting against a well-equipped German Air Service, the aircraft of No 1 Squadron were initially no match for the faster and better performing German aircraft types. However, when the squadron was re-equipped with the superior Bristol Fighter in late 1917 they, together with other RFC squadrons, were soon able to take the fight to the enemy and eventually gained air supremacy, enabling General Allenby's ground forces to sweep across Palestine that eventually led to the Turkish defeat.

Of significance, the Victoria Cross was awarded to Lieutenant Frank McNamara of No 1 Squadron for the heroic and selfless rescue of another Australian pilot, Lieutenant David Rutherford who had just been shot down. McNamara, despite being badly wounded, 'swooped down' to pick up Rutherford while under Turkish fire. The incident is now captured for posterity on the No 1 Squadron's badge, the diving Kookaburra representing McNamara's remarkable 'swooping' feat.

The Squadron rendered stirling service in the Middle East and in its ranks were seven members later knighted for their service to the nation. Among them was Lieutenant Colonel, later Air Marshal, Sir Richard 'Dicky' Williams, the father of the Royal Australian Air Force.

# The Australian Flying Corps: Part II (#248)

In Pathfinder Issue 246, the genesis of the Australian Flying Corps and its service in the Middle East was covered with a focus on values. In this Pathfinder, Australia's provision of three fighting squadrons and four training squadrons to the European Theatre will be discussed under the lens of adaptability.

While the Australian airmen were pioneers over the Middle East, in Europe, they were latecomers. After the success of No 1 Squadron in Egypt, in mid-1916 Australia was called upon to send further formed squadrons to help with the war effort, this time to assist over the Western Front. By 1916, the war had ground to a stalemate of stagnant trench warfare. Air power offered the only practical means of taking the war to the enemy. Eventually three fighting squadrons Nos 2, 3 and 4 AFC would be sent from Australia and four training squadrons; No 5, 6, 7 and 8 AFC would be formed in England.

Nos 2 and 3 Squadrons were the first of these Western Front fighting squadrons, formed within one day of each other. No 2 Squadron was manned partially from volunteers of No 1 Squadron that were still based in Egypt and a few airmen from the Mesopotamia Half Flight. The squadron was dedicated to

**Key Points**

- *The RAAF's traditions stem from its army roots since the RAAF was formed by the men of the AFC and other Australian airmen who had served in British units.*
- *The adaptability and ingenuity shown by these pioneers in the way they took the fight to the enemy carries forward to the RAAF of today.*
- *The AFC's decision to train and prepare airmen for the Western Front from within the theatre was a wise one given its great distance from Australia and the differences in the prevailing environment.*

the Army support role as a fighting or scout unit and was attached to the British Third Army. Their first major battle was that of Cambrai on 20 November 1917 where they carried out patrols, strafing of enemy troops and bombing runs. Seven out of the total strength of 18 aircraft were shot down—not an auspicious start. Nevertheless, No 2 Squadron went on to distinguish itself claiming 185 enemy aircraft by war's end. Equipped with DH5s and later the better performing SE5A, the squadron was involved in all the major offensives in their sector of the Front.

Meanwhile, No 3 Squadron had arrived in France in September 1917 and was equipped with the venerable RE8 reconnaissance biplane. The Squadron was dedicated to the role of reconnaissance and artillery spotting. Within days of their arrival, the squadron was in action over the Douai Sector. Although not equipped with fighters, the unit succeeded in destroying at least 16 enemy aircraft and claimed a further 'unconfirmed' 35 sent out of control. One of those victories was an Albatros DVa, captured intact which is now on display at the Australian War Memorial.

The squadron's main claim to fame was their operations during the Battle of le Hamel in 1918. Supporting General Sir John Monash's push to end the war, the squadron developed the means of aerial resupply of ammunition to the advancing troops and provided photography of the front to aid mapping and manoeuvre, while continuing to carry out their designated reconnaissance role.

The final squadron to arrive at the Front was No 4 Squadron, also dedicated to aerial fighting and scouting. Attached to the British First Army from late 1917, the squadron was involved in countering the German counter offensive launched on 21 March 1918. The squadron was tasked in support of the Australian 4th Division with low level bombing and strafing to mask the approach of British tanks. As the war came to its climax, and with the Germans in retreat, No 4 Squadron continued to pursue the remaining German Air Service at every opportunity. On 29 October, during what was one of the largest aerial encounters, 15 Snipes from the squadron engaged 60 German aircraft over Tournai. The melee, lasting only minutes, resulted in the shooting down of 10 of the enemy for every own loss. The squadron would end the war with a tally of 199 enemy aircraft shot down. The most successful AFC pilot was Captain Arthur 'Harry' Cobby of No 4 Squadron who claimed 29 enemy aircraft destroyed. He went on to join the RAAF, served in the Pacific in World War II and rose to the rank of Air Commodore.

Along with the provision of operational squadrons to the conflict, Australia also conducted its own training. Initially, pilots, observers and technical airmen were trained in Australia, and after time spent in England to prepare for the Front, joined one of the AFC squadrons under the command of the RFC in France. As the war progressed and casualties mounted, so high was the demand for pilots and observers that a decision was made to constitute four Australian flying training squadrons in England with trainees being recruited from amongst volunteers from the ranks of the Australian army battalions. Two aerodromes in Gloucestershire were established for the purpose and an AFC training depot was established at Halton to train aircraft mechanics. As well as training new pilots, the schools also provided pre-deployment training to airmen who had previously qualified in Australia.

Australia resisted the British policy to absorb all Dominion airmen into the Royal Flying Corps squadrons by establishing and maintaining her own combat and training squadrons, the only Dominion to do so. Nevertheless the RFC insisted in numbering these Australian squadrons with RFC numbers, much to the disgust of the Australian airmen. This has often led to confusion in official records, though in reality the Australians always called their unit by its original AFC number.

The officers and airmen of the AFC would return to Australia to become the founders of the Royal Australian Air Force. Many of the technical airmen who also joined brought with them the skills necessary to ensure the RAAF would remain a capable and responsive force.

By the end of the Great War, over 3700 Australian airmen had fought in the AFC for King and Country and possibly another 1500 or so with the Royal Naval Air Service, the RFC and later, the RAF. Sadly, 217 paid the ultimate price.

# Australian Flying Corps in New Guinea (#234)

The formation of the Australian Flying Corps and Central Flying School was considered by the Military Board on 11 September 1912, and approved on 20 September. Army Order 132/1912, issued on 26 September, officially brought both the school and corps into being. The existence of the new military flying school at the outbreak of World War I made it possible for the Australian Government to contemplate the conduct of actual air operations within Australia's area of responsibility.

And so it was that not long after the outbreak of war that Australia's first aviation unit was being readied for active service and deployment overseas. A month before the first course at Central Flying School had completed training, the government decided to raise a 3rd Battalion of the Australian Naval and Military Expeditionary Force (AN&MEF) to relieve the contingent that had seized Germany's colonial territory in New Guinea, shortly after the war started. This battalion became known as the 'Tropical Force'.

In late November 1914, in the week before Tropical Force was due to depart, information was received about a large German garrison and two armed vessels that were 60 kilometres inland on the Sepik River. In view of this

**Key Points**

- *Formation of the AFC and CFS made it possible to consider air operations in Australia's area of responsibility.*
- *Although the aircraft were not employed in this case, the deployment to New Guinea demonstrated the AFC's ability to carry out expeditionary operations and paved the way for future operational deployments of AFC units.*
- *The ability to deploy was an early demonstration of the flexibility of air power in providing the Government with different options in the pursuit of national security.*

development, Tropical Force's objective was changed and it was ordered to capture the German outpost. A hastily assembled aviation unit was attached to the Tropical Force to assist with reconnaissance upriver.

On 27 November Lieutenant Eric Harrison, one of Central Flying School's instructors, was appointed to lead the small aviation unit, which included newly graduated pilot Lieutenant George Merz and four mechanics, including Sergeant Shorland and Private McIntosh. All six personnel were attested full members of the AN&MEF. The following morning the flying school's staff sent two reconnaissance and training biplane aircraft—a government owned BE2 and a Maurice Farman Hydroplane donated to the war effort by the entrepreneur Lebbeus Hordern—along with a full complement of spare parts, fuel and all other necessary gear, to Sydney via rail to board HMAS *Una*, the first RAN warship to carry aircraft. HMAS *Una* was the captured German naval yacht *Komet*.

With army authorities anticipating a 'decent scrap', the air party readied themselves in preparation for possible action during the voyage north. The primary role of the air element was to observe and gather intelligence. As prepared landing fields were unlikely to be available, and with the surrounding terrain being unsuitable for aircraft operations, the aircraft were expected to operate as floatplanes. However, only the Maurice Farman was a seaplane. Therefore, plans were drawn up on board the ship to convert the BE2 to a seaplane en route, although they were not implemented.

Tropical Force had been given the initial task of ousting a reported German wireless station remaining on the Sepik River. In anticipation of more robust action, Harrison and two of the mechanics fitted fixed propellers to the back of a number of 16-kg lyddite artillery shells to convert them into bombs. These propellers ensured that the shell would follow a straight trajectory to the target with the propeller serving the same purpose as the bore of a rifle. However, upon arrival at Madang on 7 December, Tropical Force's Commanding Officer, Colonel Samuel Pethebridge, learned from a pair of German missionaries that there was no such enemy garrison on the Sepik River. The alleged enemy base was found to be based on fraudulent information by a paid informer that was passed on to intelligence authorities in Sydney. Disheartened by the deception, the force was then sent on to Petershafen, on Witu Island north of New Britain, and then on to Rabaul. All through this voyage, the aircraft remained in their crates.

The General Staff subsequently prepared to scale down operations in the Pacific and reduce the AN&MEF to a garrison force. On 20 December Colonel Pethebridge cabled the Defence Department explaining that he no longer needed the aircraft. By the end of 1914, all German posts in New Guinea had been occupied, and German New Guinea was placed under Australian military administration. Although this was a subject for much congratulations among the officers commanding the naval and military operations, the fact that the aircraft were never needed caused great disappointment to the aviation staff.

The two aircraft remained in their crates at the Customs House in Rabaul, and were returned to Australia unused, along with their crews, in mid-January 1915. On its return to Australia, the Maurice Farman was allocated to the Central Flying School at Point Cook. At the time the Central Flying School syllabus did not include the training of seaplane pilots, and therefore further use of the aircraft in the maritime role remained very limited. The aircraft's floats were later removed and ultimately the aircraft was converted to a land trainer.

The aviation deployment was kept secret until the personnel returned to Australia, and Harrison's absence was explained by a cover story that he was on his honeymoon after his recent marriage. The team's health had also suffered during the deployment. Although all personnel had been inoculated against typhoid, the small aviation team all returned suffering from the effects of malaria.

Although this initial opportunity to lay the foundation of a tradition for Australia's fledgling air corps proved abortive, a second chance immediately arose. In February a request was received from the Government of India for aerial assistance during a planned campaign in Mesopotamia (modern Iraq). The Australian government agreed to help, despatching what became known as the Half-Flight, AFC, from Melbourne on 20 April 1915.

# RAAF Liberators and Long-Range Strikes (#222)

The ability to conduct long-range strike missions on adversary targets is a fundamental role of all well-balanced air forces. During World War II, wider strategic factors prevented the RAAF from developing this capability until February 1944. During that month the first of a growing fleet of B-24 Consolidated Liberators began arriving in Australia for service in Air Force colours. Arguably one of the finest long-range heavy bombers of the war, acquisition of the B-24 aircraft provided the RAAF the ability to range widely across the South West Pacific Area (SWPA) of operations attacking targets previously out of range of the medium bombers then in Australian service.

The arrival of the B-24s in Australia did not in itself immediately bestow a long-range strike capability upon the RAAF; it also required a training and development process in many ways similar to that of contemporary examples. The first Australian crews were sent to a United States Army Air Force (USAAF) B-24 operational conversion unit at Charters Towers, QLD in 1943, followed by a deployment with the 43rd Bombardment Group of the US Fifth Air Force. These crews were soon part of the relentless attacks by USAAF aircraft

**Key Points**

- *Any RAAF capability requires personnel, training and a complimentary support network to be operationally effective.*
- *The ability of air power to generate effects over a wide region from airbases remote from the theatre of operations provides a strategically effective, operationally flexible and tactically invaluable set of options to Government and Defence planning.*
- *Capable, long-range strike aircraft provide individually flexible platforms, which can provide a disproportionate effect in relation to the size of the fleet.*

on Japanese held airfields and other major targets throughout New Guinea. Deployments to other B-24 USAAF units were to follow, all resulting in the RAAF gaining significant experience in operating the B-24. Many of these crews were in turn posted to the RAAF's newly formed No 7 Operational Training Unit at Tocumwal, NSW as instructors in order to contribute to the training effort as the RAAF built its long-range bomber capability.

As the number of trained crews and available airframes increased through 1944, Nos 21, 23 and 24 Squadrons, RAAF were converted from operating the Vultee Vengeance on to B-24 long-range strike and reconnaissance aircraft. By July 1944, five months after receipt of the first B-24 into service, RAAF crews of No 24 Squadron, the first RAAF unit to be equipped with the B-24, were ready to commence operations to Australia's north. The effects generated by the new long-range strike capability were immediate and obvious. Targets previously out of range were attacked and armed reconnaissance missions conducted over areas that had only seen minimal Air Force presence in the past. These missions resulted in the destruction of several freighters, barges and shore installations.

While contributing to the overall tactical successors of the Allied air operations in the SWPA, the real capability of the RAAF's long-range heavy bomber was still to be utilised to its full strategic potential. This changed in January 1945, when after extensive planning and intelligence assessments, followed by two weeks of continual training, six B-24s of No 24 Squadron were dispatched on a 3700 km round trip from Truscott airfield in WA, to attack the Mendalan and Siman hydroelectric power stations at Kali Konto in occupied Java. Responsible for providing nearly half of Java's electricity requirements and one of the largest hydroelectric power plants in the world, the strategic importance of the Mendalan and Siman power stations was first identified through assessments carried out by the Central Intelligence Unit in Brisbane, and later through analysis of aerial reconnaissance imagery obtained by the RAAF's No 87 Squadron. It was determined that the loss of these power stations would disrupt Japanese manufacturing, industry and military operations throughout the Java region.

The plan called for three waves of attacks, each of two aircraft, on the power stations to be conducted on 27 January 1945. The second and third waves were only to be conducted based on an assessment of the damage caused by the previous wave. As it transpired, only the first wave of attacks were made, with adverse weather causing the follow on attacks to be cancelled, although this was sufficient to put the power stations out of action, at least temporarily, with the B-24 of GPCAPT Kingwell striking the transformer yard and turbine house of the Mendalan plant, while FLTLT Kirkwood and crew damaged the generators and workshops at the Siman facility.

An interesting sidenote to Kirkwood's post-operational report was the identification of a dummy facility constructed to the north of the Siman facility. Kirkwood noted: '*Observation of the dummy power house north of the target showed the wall had not been continued to the ground level and that it was possible to go through and under the building.'* This attempted deception and extensive camouflage of the primary targets were the only defensive measures taken to protect the targets, with both crews reporting that no anti-aircraft fire or enemy fighter aircraft were seen. However, if the fighters known to be in Java had failed to disrupt the mission, the weather which had prevented the second and third waves from taking off nearly put paid to a successful return to base of the two B-24s and crews. Severe thunderstorms marked the return trip to Truscott, delaying the RTB by nearly two hours. On landing, Kirkwood's port engine stopped due to fuel starvation. Post-flight inspections found only 22 litres of fuel remaining in the aircraft.

The fuel needed to reach the power stations was in fact an issue throughout the planning process. The standard fuel load of the B-24s was insufficient for the mission, however crews with experience in the RAF's Coastal Command were aware of the B-24's ability to carry additional fuel tanks in lieu of bombs in its rear bomb bay, while still leaving the forward bomb bay free to carry six 250-kg bombs. This inherent flexibility of the aircraft provided the key to being able to push ahead with the mission planning, and resulted in the 3700 km bombing raid becoming the longest mounted from the Australian mainland during World War II.

In the post mission debriefs it was determined that a second attack should go ahead within 24 hours; however, the weather once again prevented this plan from being executed. Instead, the target was granted a nine-day reprieve. On 5 February the second attack was launched, once again from Truscott. The key difference this time was that it was planned for four aircraft to attack simultaneously. While hits on the wider infrastructure were observed, little significant damage was achieved on the power stations themselves. Consequently, a third attack was planned and conducted on 8 February. This last attack was spectacularly successful, with good hits observed from all four aircraft on both the Mendalan and Siman power stations. With post operation analysis confirming that the power stations were now expected to be out of commission for a prolonged period of time, no further attacks were considered necessary.

The RAAF's B-24 crews were to continue flying for the remainder of the war, carrying out attacks on Japanese garrisons, supply vessels and supporting Allied landings in Borneo. While other, smaller RAAF aircraft were able to conduct similar raids, none could achieve the reach, penetration and effect as simply or as effectively as the long-range, hard-hitting B-24 Liberators.

# The P-3 Orion in RAAF Service: Flexible Air Power in Action (#250)

**Key Points**

- *The RAAF's P-3 fleet has exhibited the characteristics of speed, reach, and precision in contributing flexibly to Australia's national interests.*
- *The decision to continually upgrade the P-3 fleet capabilities over the years has allowed Australia to contribute to combat, air support and humanitarian operations around the globe.*
- *The P-3's ability to switch roles, sometimes while airborne, is a significant force multiplier for the ADF.*

Introduced into RAAF service with No 11 Squadron in 1968, the Lockheed P-3 Orion has since delivered a versatile, long endurance, maritime and over land surveillance and response capability to the Royal Australian Air Force. Larger and faster than the P-2 Neptunes they replaced, the Orions have provided a far more comfortable crew environment and the opportunity for further capability development as technology has evolved. Ten P-3C Update II Orions replaced No 10 Squadron's ageing SP2H Neptunes in 1978 while 11 Squadron's P-3Bs were replaced with 10 P-3C Update II.5 Orions in 1984–85.

While the P-3 was originally fielded as a land-based maritime patrol aircraft, in RAAF service some of its missions, largely conducted from remote bases, have evolved in response to changing threats and national security requirements.

Inheriting the anti-submarine warfare role from the P-2, the Orion's greater reach and speed saw active RAAF P-3 involvement in Cold War Anti Submarine Warfare (ASW) operations far from home: in the North Pacific, the North Atlantic, the Indian Ocean and elsewhere. After qualifying against 'tame' USN submarines, RAAF crews flew from Canada, continental USA and Hawaii, as part of Cold War operations that located, classified and tracked Soviet attack and ballistic missile nuclear submarines. Closer to home, RAAF P-3 crews conducted similar operations against Soviet attack submarines transiting the waters of our region.

Operating the P-3B, with its greater speed and reach, Australia was at last able to fulfil its surveillance obligations under the 1951 Radford-Collins Agreement that provided for the shared responsibility for the protection of shipping and sea lines of communication in the strategically important South Pacific and Indian Ocean areas. Similarly, Australia now had the capability to reconnoitre the maritime expanse associated with its Exclusive Economic Zone declared in 1973, which was an area exceeding Australia's land territory. Subsequently the P-3's evolving capabilities have been exploited in a host of ISR operations both in the traditional maritime domain and more recently, over land.

Operation *Estes*, which commenced in 1980, involved P-3s in round the clock surveillance of Bass Strait oil rigs against an assessed terrorism threat. Further afield, in the wake of the December 1979 Soviet invasion of Afghanistan, Butterworth-based Operation *Gateway* commenced in February 1981 and is now the ADF's longest continuously running operation. Throughout *Gateway*, RAAF P3s have located and tracked submerged submarines operating in their area of responsibility and conducted ISR operations against a variety of surface targets. The sharing of intelligence from these operations with long standing allies and regional partners has firmly established Australia as a trusted member of alliances and arrangements such as ANZUS and the Five Power Defence Arrangements. These operations were not without hazard: RAAF P-3s, while not armed on these missions, were occasionally engaged by small arms. Further, the changing tones routinely heard by RAAF Orion crews of hostile missile radars that had acquired, tracked and locked onto their aircraft were a chilling reminder of the potential for their aircraft to be engaged by more potent weapons.

RAAF P-3 surveillance operations in the South-West Pacific have long fulfilled a broad diplomatic agenda. In safeguarding the natural resources of island states which lack the necessary assets to discharge this role, Operation *Solania* maritime surveillance by RAAF P-3s has been a tangible expression of Australia's standing as a reliable neighbour and regional partner. Strategically, the presence of RAAF

P-3s engaged in these patrols has provided a counterweight to the activities of other nations exploiting opportunities in the region.

Over the years Australia's credentials as a dependable member of the international community have been further reinforced by Orion participation in countless rescues at sea. Prominent among these have been the rescues of solo yachtswoman Isabelle Autissier in 1995, some 900 miles south of South Australia, and even more challenging, the rescues of three yachtsmen, Dinelli, Dubois and Bullimore in the 1996/97 Vendee Globe solo-handed round the world yacht race. In the Vendee case, each had capsized approximately 1200 miles south of Western Australia.

In their long service life with the RAAF, P-3Cs have increased capability and airframe life through a process of continuous upgrades. Least visible of these have been indigenous software upgrades. RAAF crews, comparing their operating software with that used by their USN counterparts were pleasantly surprised to learn that the relatively small size of the RAAF P-3 force was offset by the ability to consult readily and agree to the software changes necessary to increase capability. Such agility is not shared by the much larger, and more dispersed USN P-3 force.

Early in their RAAF service life, the P-3C's well established surface surveillance capability was enhanced with a maritime strike capability when the aircraft were armed with the AGM-84 Harpoon missile. A P-3C became the first RAAF platform to fire one of these weapons when it engaged an exercise target at sea near Hawaii on Anzac Day 1982. Subsequent upgrade projects have included installation of the advanced Elta ALR-2001 Electronic Support Measures system; and in 1995, a capability assurance program which contributed to the life extension and enhancement of the military capabilities of the renamed AP-3C Orion fleet. Along with the introduction of sophisticated electronic warfare self protection systems and continuing upgrades to the aircraft's electro optics/infra red system, other enhancements to the aircraft made it a particularly effective ISR platform throughout coalition operations in the Middle East Area of Operations. Between 2003 and 2012, AP-3C crews won great accolades for their operations both over land and in the more traditional maritime role for ISR missions, routinely being tasked in both environments on the same sortie.

In view of the P-3's design stemming from that of the Lockheed Electra passenger aircraft, no description of RAAF P-3 operations would be complete without reference to the Orion's air mobility roles. In the nearly 50 years since their arrival at Edinburgh, these have included countless aeromedical evacuations across the region, exploitation of the aircraft's inherent self-deployment capability to fly to different bases with its own support crew, acting as a navigation and communications platform for long transits by less capable platforms and on occasion, unusual passenger transport tasks. Perhaps the most unusual of these occurred in August 1974 when Russian musician, Georgi Ermolenko, seven colleagues and a DFAT officer were ferried from RAAF Pearce to Singapore in an 11 Squadron P3B. Unions had banned commercial flights from taking Mr Ermolenko out of Australia when he changed his mind after earlier seeking to defect to Australia. Flying to Singapore, the 11 Squadron crew decided they had identified the KGB officer they were convinced would be accompanying Mr Ermolenko. The next day the 'KGB man' returned to Australia on the P-3—he was the DFAT officer!

Throughout their long history of service with the RAAF, P-3s, employed in three of the four core air power roles—ISR, strike and air mobility—have epitomised the flexibility of air power.

# C-130A: Agent of Transformation (#250)

**Key Points**

- *The C-130A initiated the transformation of the RAAF's training, personnel organisation and operational practices even before the introduction of the Mirage III and F-111.*
- *The revolutionary leap in airlift capability enabled by the C-130A provided the ADF with a quantum improvement in operational capabilities.*
- *The C-130A offered Government opportunities to increase Australia's influence and image within the region, particularly in the provision of HADR.*

In public perception, the modern fighter aircraft portrays sophisticated technology and revolutionary changes in air power and air forces, while transport and maritime aircraft seem staid and, at best, evolutionary. From the beginning, air shows have been filled with stunning demonstrations of new and better fighters (and occasionally bombers) reinforcing the belief that new fighters are the agents of change for an air force. The introduction of the Mirage III in 1963 and the F-111C in 1968, is commonly considered to be the beginning of the RAAF's transformation into a world-class, modern air force. Both these aircraft had state-of-the-art engines and airframes and both were equipped with advanced and complex weapons and avionics. They demanded from the RAAF highly trained, specialist aircrew and technicians generated by a disciplined and dedicated training organisation. If transformation of an air force is characterised by these traits then the transformation of the RAAF started well before the introduction of the Mirage III. It can be said that the introduction of the C-130A into RAAF service in 1958 first demonstrated these traits and started the RAAF's transformation.

The massive improvement in performance of the C-130A over the C-47, which was then the workhorse of the RAAF, was a revolutionary change for the airlift community. With its greater speed, range and payload the C-130A immediately influenced the way in which the ADF and other national agencies met the Government's requirements, with the impact being felt from the national strategic to the tactical level.

For a resource-constrained post-war air force whose training habits were somewhat informal and not overly systematic, the first RAAF C-130A crews experienced a cultural shock when they came across the disciplined, modern and technology-enabled USAF training system. Earlier, conversion to the C-47 was somewhat more haphazard, as noted in AIRMSHL SD Evans' autobiography. 'Is there a course I have to do before I go flying?' asked the then Flight Sergeant Evans. 'No, go and get a set of pilot notes…' was the response. On the introduction of the 'C-130A method' there was realisation that this was the future for the RAAF training system. Soon USAF-style conversion courses were established in Australia, leaving behind the older informal ways. The extensive use of simulators by the USAF airlift community was a model the RAAF also adopted for its C-130A conversion training. With both the Sabre and C-130A programs successfully using simulators, the RAAF was spurred to adopt simulator-based training for other aircraft, notably for the P-3B, C-130E and F-111. Training was leading the transformation of the RAAF.

While the task of loading a Dakota was complex and labour-intensive, the sophisticated loading systems of the C-130A demanded a quantum increase in aircrews' knowledge and skills. It was realised that to make best use of its load carrying capacity specialist knowledge was needed, and the RAAF rapidly trained selected personnel as loadmasters on the new airlifter. This concept ultimately resulted in the formal introduction of the Loadmaster mustering in 1983. The aircraft's systems were similarly generations ahead of its predecessors, and the Allison T-56 turbo-prop engine was the first turbo-prop used on a military transport. To manage the new engines and systems, a new generation of flight engineers were required with skills over and above those of their World War II era forebearers. The move to more specialised aircrew was a taste of things to come—effective application of air power demands deep professional mastery at all levels.

In comparison with the C-47's performance, the C-130A offered previously unimagined capabilities. The Dakota, whose contribution to the Allied victory in World War II is unquestionable, was nevertheless an aircraft that reflected the design and performance of the 1930s. The new levels of speed, reach and payload—all enduring characteristics of air power—provided by the C-130A forced massive changes to planning and operational concepts across the ADF.

With a cruise speed over twice that of the C-47 and a greatly enhanced range, the ADF now had much greater flexibility in reacting to emerging challenges. The long distances within Australia and the region had always been a significant, and limiting, factor in the ADF's reactive capability. The C-130A's speed now markedly reduced reaction times.

The fivefold increase in load capacity of the C-130A, in relation to the C-47, fundamentally altered the ADF's concepts of strategic air movement. Passenger numbers increased from 28 in the Dakota to 92 for a C-130 (and more if combat loaded) and allowed military forces to arrive quicker and with more combat power at an operational location. For the ADF, contemplating operations in infrastructure-poor South-East Asia or PNG, the C-130A was a boon for planners and deployed forces alike. In the 1950s, Australia's commitments in the region were extensive, which included administering PNG, and contributing to SEATO, Commonwealth Strategic Reserve, and the Malayan Emergency. The performance of No 36 Squadron's 12 C-130As provided the nation, for the first time, a true strategic airlift capability to match those demands.

The C-130 had a truck-height cargo floor and the ability to lower the cargo ramp in flight. Later, the 463 L pallet and parachute-extracted, air drop system were introduced making airlift itself a force multiplier. The 463 L system subsequently became the basis for the concept of roll-on, roll-off airlift cargo systems. The C-130 fuselage cross-section was designed around loads, which helped reduce the time needed to prepare and load cargos. For deployed forces materiel now arrived not only quicker but also in a state that allowed more rapid use at the destination.

Most airlift specialists of the day understood that the C-130A would transform their part of the RAAF but little did they realise that the aircraft and its capabilities would directly affect the whole of the

RAAF, the ADF and parts of the Government. With the advent of modern training systems and specialist trades the transformation of the RAAF into a modern and capable force had begun. The C-130A did not simply evolve RAAF airlift but revolutionized it in a way not seen again for many years. Within the Australian military, the aircraft's performance opened up a new range of operational possibilities. With such a platform, the RAAF, and hence Australia, was now able to react more rapidly to evolving situations.

For the non-military agencies of Government dealing with Humanitarian Assistanace and Disaster Relief (HADR), the C-130A's capabilities offered the means to positively influence the region. In times of need the C-130A could reach the troubled area quicker and carrying more relief supplies than before. The image of the C-130A reflected what the Government sought to project–a modern, strong, reliable and non-threatening neighbouring nation.

The C-130A was the first agent of transformation in the post-World War II RAAF at all levels, from tactical military missions to influencing strategic decisions in providing Australian aid into the region. It brought about changes in RAAF practices that would affect personnel, training, logistics and operational employment, all of which would be replicated in the induction of future aircraft.

# The Selection and Construction of the CAC Sabre for RAAF Service (#236)

In response to the global transition to the jet age, and the need for Australia to replace its obsolete fighter force of P-51 Mustangs and De Havilland Vampire aircraft, the Australian Government announced on 8 February 1950 the decision to purchase 72 Hawker P.1081 fighter aircraft, to be built under licence by the Commonwealth Aircraft Corporation (CAC). This announcement came as a surprise to the Board of the CAC. They knew the RAAF was seeking a replacement fighter aircraft, and had researched options for such an aircraft, including the design and manufacture of their own aircraft and the licensed manufacture of an existing aircraft from overseas. However, the decision to purchase the P.1081 was made without consulting the Board of the CAC. The ambitious acquisition schedule of only 18 months from the date of the announcement to expected introduction into RAAF service further compounded the challenges facing the CAC.

**Key Points**

- *The CAC Sabre was Australia's first swept-wing, second generation, jet aircraft. Capable of supersonic speed in a dive and armed with modern air-to-air missiles, it was considered to be one of the most capable variants of the F-86 aircraft.*
- *The modification and manufacture of the CAC Sabre in Australia represented a high-water mark for Australia's aviation industry.*
- *The relationship between CAC, RR and North American Aviation was a portent of the progressive globalisation of the civil Defence industry.*

The head of the CAC, Lawrence Wackett (later Sir Lawrence), realised the proposed schedule was ambitious, if not completely unrealistic. The design specifications of the P.1081 were not finalised, the prototype was yet to fly and manufacturing infrastructure had yet to be completed. Wackett was aware, however, that the CAC needed the contract to continue to be financially viable. He sent a party of CAC engineers to the Hawker factory in the United Kingdom to complete the licensing arrangements. Although the prototype P.1081 made its first flight in June 1950, by August the CAC team in the UK was reporting the project was in difficulties. The development delays, combined with the lack of UK Government interest in the P.1081, made the Australian Government decide to cancel the P.1081 purchase.

In parallel to these events, the CAC had developed a business relationship with Roll-Royce. Roll-Royce had bought shares in the CAC in 1948 and Wackett, considering this "a great compliment", was keen to keep building their engines under licence. CAC was supplying the Nene for the Vampire and the licence eventually extended to the Avon engine for use in the newly ordered Canberra. With access to a modern jet engine secured, Wackett turned his attention to an aircraft suitable for licensing and meeting the RAAF's requirements.

Hawker offered an alternative design, the F3, later named the Hunter, in place of the P.1081. However, Wackett argued that as Australian deliveries of the F3 could not be effected before mid to late 1954, an American aircraft design should be considered instead. The Australian Government remained firm on its requirement to purchase British equipment and with nothing available, additional Vampires and the Meteor were acquired to fill the RAAF's needs, particularly to counter MiGs in Korea.

Dissatisfied with the state of affairs, Wackett continued to look at manufacturing a capable modern fighter for the RAAF. Wackett had experience in dealing with the North American Aviation company through licensed manufacture of Wirraway and Mustang aircraft. Wackett determined that the latest product from the company, the Sabre, had the proven design and performance best suited to filling the RAAF's fighter requirements. With no official backing from the Australian Government, Wackett travelled to the United States to meet with representatives from the Pentagon and the North American Aviation plant in California. Receiving strong encouragement for the Sabre deal, Wackett worked to convince the Australian Government of the Sabre's benefits. On return to Australia Wackett, through the CAC, submitted a proposal to the Air Board for the licensed manufacture of the Sabre with the RR Avon engine. While the Air Board agreed in principle, it wasn't until a phone call from Lord Hives of RR to the Minister for Air, Sir Thomas White, that the Government became committed to the Sabre aircraft, announcing the purchase decision on 22 February 1951.

The CAC Sabre was based on the F-86F model. With the substitution of the General Electric J47 power plant with the Avon engine, the CAC knew that the airframe design would require major modifications. It fell to CAC's engineer Ian Ring and his team to make the amendments. A total of 268 engineering changes were made to the original F-86 design to create the Avon-Sabre prototype. The Avon engine was lighter and shorter, but with greater diameter than the J47. The engine needed to be moved rearwards, but still remain supported by the fuselage. By shortening the rear portion of the fuselage by 66cm and adding this amount to the front, the aircraft's original centre of gravity and overall length was maintained. The Avon provided more thrust than the J47, necessitating the enlargement of the air intake. This was achieved by splitting the front fuselage horizontally and inserting a 9.47cm wedge into the space. The modification avoided having to make changes to the cockpit arrangements and had the added benefit of raising the nose during the take-off roll and improving the Sabre's airfield performance.

Another significant change was to the armament. While the original F-86 carried six .50 inch machine guns, the CAC Sabre was intended to carry four 20mm Hispano cannons. This was subsequently amended to the newly developed Aden 30mm cannon. This change added three months to the development program, but the RAAF considered it worthwhile.

The first ground run was conducted on 20 July 1953 and by August that year the prototype was ready for its first flight. The CAC airfield at Fishermans Bend in Melbourne was too short for the Sabre's flying trials, so the aircraft was dismantled and trucked to the Avalon airfield and reassembled. Allocated the number A94-101, the first CAC Sabre flew on 3 August 1953 with FLTLT William Scott at the controls and the flight lasted 30mins. On 14 August 1953, again with Scott as the pilot, the aircraft broke the sound barrier for the first time in Australia during a shallow dive.

As with any new project early tests uncovered unforeseen problems such as engine surges at high altitude and when the guns were fired. Innovative improvements ensured that the RAAF received a capable and locally made fighter comparable to similar equipment made overseas. Further modifications were eventually made to include the carriage of infra-red air-to-air missiles. While consideration was given to equipping the Sabre with air-to-air missiles early in its design phase, it was not until 1956–57 that tests were carried out comparing the US made Sidewinder against the UK's Firestreak missile. The Sidewinder was selected and issued to the squadrons from February 1960.

The first of an eventual 112 aircraft was handed over to the RAAF on 30 August 1954 and the last on 4 August 1961. The Sabre remained in RAAF service until official retirement on 30 July 1971, being replaced by the GAF built Mirage IIIO. The CAC Sabre proved itself to be an excellent aircraft if obsolete by the late 1960s and marked a major milestone of aircraft manufacture in Australia.

# Combat Control in the RAAF (#224)

> **Key Points**
>
> - *The effective use of air power during Special Operations requires dedicated professional air power specialists.*
> - *The advent of combat controllers is a relatively small investment that has significantly enhanced air operations.*
> - *Air power employment has been made more effective and has covered an increasing range of roles through more precise application of air effects in the air/land battlespace.*

Air power is a scarce resource that needs to be carefully managed to generate the best possible effect, especially when employed in conjunction with maritime and land forces. Given this limitation of resource, centralised control and decentralised execution are critical tenets in the application of air power. However, for this to routinely occur at a tactical level, an air component specialist is needed to plan, coordinate and execute the generation of air effects. To this end the RAAF created the combat controller mustering in 2010 whose role is primarily to coordinate the generation of air effects. While this role is often centred on providing kinetic effects for surface forces, combat controllers also conduct tasks that permit the use of expedient airfields in both war and peace.

The rapid development of air power capabilities during recent conflicts, especially in Iraq and Afghanistan, has offered new possibilities to the joint force commander in the prosecution of the land battle. Land forces and in particular Special Forces, have had the opportunity to train, fight and generally become familiar with air assets especially in situations where close air support and airlift are required. However, the combat advantages offered by the rapid advances in airborne capabilities, particularly of intelligence, surveillance and reconnaissance platforms, has placed increasing demands on air power.

The Australian combat experience during the early phases of operations in Afghanistan showed that a more co-ordinated approach in meeting demands for air power requests was required. The experience highlighted that the provision of integrated combat air power for Special Operations required a detailed and in-depth understanding of all aspects involved in connecting air and land power to joint operations. Without this being established, the desired air effects provided to the supported commander may not be optimal and, may not provide the critical and timely impact needed on the battlefield.

The battlespace is becoming increasingly complex and as the capabilities of air platforms improve, the need for closer integration between the air and land power becomes critical. However, the enhanced capabilities that modern air assets can provide means that fewer platforms are necessary to achieve the same result. In turn, fewer platforms require more precise planning in prioritising tasking requests. As platform numbers reduce there can be a tendency to dilute the force by spreading the platforms evenly across the supported commanders. However, this would be a wrong concept. Air power that is focused, integrated and combined into land operations that can create disproportionate effects—that is, Special Operations—results in improved mission success rates and increases the chances of overall progress of the campaign.

The demands placed on air power by Australian field commanders are not new. While the RAAF's World War II history shows that army co-operation squadrons existed to meet the varying demands on air power, this capability was not sustained in the post war period, and degraded quickly after the cessation of hostilities. Today, the alignment of airborne systems in the air/land battle has become too significant and central for it to be re-learned during each new operation. The skill of successfully integrating airborne systems into the joint battle is not one that can be readily learned as it must be practised and understood at all levels of the process or the field commander is likely to lose the advantage sought from the desired air effect.

To meet this demand on airborne systems, a dedicated, skilled specialist workforce of professional airmen who are practised in land manoeuvre is required. In essence, they are the professional masters of, and advocates for, air effects for the commander. They must be able to work at all levels of Special Operations, and if necessary, operate independently in support of other air elements to deliver the desired effect where and when required once assigned an air asset.

Unlike the post-World War II experience, the RAAF has established, and is committed to maintaining, a core of specialist experts who can maximise air effects in the air-land battle. This expertise is enhanced by drawing the experience of other nations. In particular, the RAAF and the USAF have developed a close working relationship to share insights.

To generate this capability for the ADF, especially in support of Special Forces, the RAAF has developed the concept of installing an individual combat controller who is resident in the combat control teams of No 4 Squadron. With extensive training and regular practice, the combat controllers have the skills and flexibility needed to conduct reconnaissance, joint terminal attack control and advanced force operations either as part of a larger advanced force or independently. Through this training they have developed an enhanced understanding of air power and what it offers for the supported commander.

While much is offered by the theoretical integration of air power into the air/land battle, validation can only be gained by operational experience. No 4 Squadron has provided individual combat controllers at the manoeuvre element level within many of the Commando Regiments' rotations. Their experience on operations in Afghanistan has demonstrated that air power effects have the most positive impact on the air-land fight when managed by those whose raison d'etre is in this role.

The integration of air power into the air/land force has historically offered enduring advantages to Australia but the lack of a dedicated professional air specialist has prevented this from being sustained. By raising and training a force of specialist professional combat controllers, the RAAF has gone a long way to ensuring that air power is most effectively and appropriately applied to support the land force commander as required. These airmen bring with them a deep understanding of the tenets of air power, and their skills act as a true force multiplier.

# Air Power's Contribution to Preserving Cultural Heritage (#238)

**Key Points**

- *The bombing of Dresden focused the UN on saving sites of cultural heritage*
- *Air power is committed to preserving cultural heritage*
- *Cultural heritage sites should be clearly marked as such*

The 70th anniversary on 13 February 2015 of the destruction of Dresden by RAF Bomber Command during World War II did not go unnoticed for the tragic loss of life and the destruction of thousands of years of cultural heritage. While the merits of this operation remain a controversial subject, one issue that emerged was the need for future bombing campaigns to preserve, where possible, buildings that represent national heritage and are of cultural significance.

The destruction of Dresden was a watershed moment for future air campaigns where cultural heritage sites became included on 'no-strike' target lists. Some progress was made with the Hague Convention of 1954 which included the specific protection of cultural heritage. However, the destruction of items of cultural significance continued and was considered collateral damage. The issue was further complicated by the fact that there was no recognised definition of what constituted 'cultural heritage'.

It was only in 1972 that the United Nations (UN) agreed on a definition. The United Nations Educational, Scientific and Cultural organisation (UNESCO) *Convention for the Protection of the World Cultural and Natural Heritage* defined 'cultural heritage' as: '... architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features… groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history ...'

The destruction of culturally significant artefacts in the Iraqi cities of Nimrud and Hatra by the Daesh (Islamic State) has been condemned by the international community to the extent that some regard this latest incident as a war crime.

In recent conflicts, air power has strived to preserve cultural heritage sites. Rapid developments in technology have created air weapons with the potential to cause widespread and permanent destruction. However, their employment today is governed by the principles of precision, proportionality, and discrimination. To this end, selective targeting in order to protect the cultural heritage of the society under attack forms a central tenet in the application of air power. Preservation of cultural heritage is an international standard that must be upheld. In a modern and cosmopolitan society cultural heritage helps to foster an appreciation of diversity, knowledge of the society and an understanding of the past. These traits are the hallmark of societal progression and therefore need to be protected.

Technology-enabled modern systems have exponentially enhanced the capability of air power to apply lethal force. Today, more than ever before, air power provides the most rapid military response available at all levels of operations—from humanitarian aid to precision strike. Air power's reach, responsiveness, precision and persistence is unparalleled. Specifically, each air power role—control of the air, strike, Intelligence, Surveillance and Reconnaissance (ISR), and air mobility—is incidental to the protection of cultural heritage. In this sense, the use of precision guided munitions to create proportionate effects and discrimination in targeting underwrite the capability of air power to minimise collateral damage. No-fire target lists are underpinned by modern intelligence systems that identify culturally significant property and shield these items from deliberate attack. Such practices are espoused in doctrine and law, and only highlight the enhanced awareness in the application of air power and the acceptance of collateral damage and destruction during earlier wars.

*'... Buildings devoted to religion, the arts, or charitable purposes; historic monuments; and other religious, cultural, or charitable facilities should not be attacked, provided they are not used for military purposes. It is the responsibility of the local population to*

*ensure that such buildings are clearly marked with the distinctive [cultural heritage] emblem ...'*

—Operations Law for RAAF Commanders, p. 68.

The UN mandate to the specificity of target lists in such operations today excludes buildings, sites and monuments of cultural heritage. Moreover, it is the expectation of the wider society that the use of aerial weaponry be proportionate and discriminatory at all times. Indeed, the precise, proportionate and discriminatory use of airborne weapons reduces collateral damage and reinforces the very legitimacy of air power, although there are some limitations in the application of such capability.

To this end, structures and sites placed on a no-targeting list requires that the adversary honour the status that is afforded to these buildings by not using the structures as bases to wage war. Further, air power may very well be a victim of its own success in such operations. Generating responsive, precise, proportionate and discriminatory options when the use of force in the other domains is unpalatable or not an available option, suggests that air power becomes the weapon platform of first choice. This is a double-edged sword and could potentially misrepresent air power's ability to shape the environment. It could lead to a distortion of the role of air power in modern conflicts. Overstating air power capability will likely result in more harm to the preservation of cultural heritage. It would be incorrect to assume that air power alone will allow the military to preserve property, protect non-combatants and defeat an adversary with a negligible commitment of ground forces.

Air power practitioners are today obliged to employ munitions for operational effect while reducing the potential for collateral damage. There is a corollary to this strategy: if there must be conflict, then protecting cultural heritage and having an understanding of the culture of the adversary reduces the potential for future war. Proportionate targeting to create the necessary effects, and the discriminatory use of kinetic air power, will contribute to the protection of cultural property for future generations. In the modern world, buildings and places of cultural significance should be guarded against deliberate attack. The role of ISR provides a persistent and in some cases omniscient view of the contemporary battlespace in which an adversary attempts to move. Persistent ISR cues potentially time sensitive targets, highlights the likely combatant from among the wider population and distinguishes culturally significant buildings and monuments. Air mobility provides the potential to transport *en masse* items of value, to relocate displaced people and to afford a level of rapid transport when required.

The preservation of cultural heritage is almost a byword in today's air power lexicon. Contemporary application of air power includes active advocacy for the rule of law, the rights and dignity of humanity, and a range of operations that lean towards the preservation and protection of cultural heritage in a secure world.

# Officer Cadet School Portsea: The RAAF Experience (#244)

**Key Points**

- *The need to maintain air base defence to sustain air power resulted in the formation of the Ground Defence category within the RAAF during WWII.*
- *The Ground Defence Officer training at OCS is an example of cost effective means to sustain an essential, but niche, capability within the RAAF.*
- *Common Joint training is a means to ensure common understanding of doctrine and tactics across all arms of the ADF.*

The majority of the RAAF's training needs are met by in-house establishments. However, a few niche training requirements have been frequently provided by Army, Navy or civil schools. Since 1983, the Royal Military College, Duntroon (RMC) has provided training for officers of one specialist category of the RAAF—Ground Defence Officers. However, for a period the Officer Cadet School, Portsea (OCS) was used to deliver the training to enhance airbase security.

The end of World War II resulted in a dramatic reduction in strength of all three Services of the Australian Defence Force. For example, the RAAF strength dropped from a wartime high of about 182,000 personnel to 7897 by December 1948. Even while the numbers were being reduced, the Defence Force still required officers to command the peacetime force. In the Australian Army a combination of graduates from RMC and remaining wartime officers initially formed the regular Army officer corps. By the early 1950's, with the advent of National Service and rising commitments in Korea, there was a considerable increase in the demand for officers. The Army was short of about 1000 officers, and RMC could not make up the shortfall. In January 1952, OCS Portsea was established to help fill the shortage.

OCS commenced with a 22-week course for future officers of the Australian Regular Army, as well as cadets from some foreign armies.

Course content was regularly updated and oriented towards providing cadets with the skills needed by junior officers in most corps of the Australian Army. Increasing training needs saw the course duration increased to 44 weeks.

During its 33-year history, OCS graduated 3,544 officers—2826 for the Australian Army and 688 for the Armies of the Philippines, South Vietnam, Cambodia, Brunei, Malaysia, Singapore, Papua New Guinea, Kenyan, Uganda, Fiji and New Zealand. Of particular note is that in addition to army officers, 30 RAAF members graduated from Portsea as Ground Defence Officers.

The creation of specialist Ground Defence officers had its roots in World War II, when RAF airfields and facilities in Europe were found to be vulnerable to attack and destruction by enemy land and air forces. As a secure base is essential for the generation of air power, the RAF acted, becoming the first Commonwealth air force to form its own ground defence units with the establishment of the RAF Regiment in 1942.

Following the RAF's lead, the RAAF created a large organisation to provide ground security for RAAF bases in Australia and the Pacific. By mid-1945, RAAF ground defence elements, as part of the First Tactical Air Force, had landed at Tarakan, Brunei and Balikpapan. This forward deployed force included five rifle companies, and medium machine gun and heavy machine gun platoons. All units were commanded by RAAF officers skilled in the doctrine and tactics of land operations. This force eventually matured into No 2 Airfield Defence Squadron (2AFDS), in which many RAAF OCS graduates would later serve.

As the post-World War II force reduction commenced, constrained RAAF resources were predominantly used to fill air operational crew. Ground Defence became primarily a part time task with only a very small cadre of specialist officers and airmen forming the core with the knowledge and necessary skills for protecting RAAF airfields. Most of these personnel were trained in ground defence operations while in service with the Commonwealth armies or air forces—the Australian Army, the RAF (in particular the RAF Regiment), the British Army and the RAAF. However, by the early 1950's this pool of experienced officers was exhausted and a search began for an alternate source.

Unlike the scale of the Army's requirement, the RAAF's ground defence category was small, making a stand-alone course, initially at least, unviable. With the establishment of OCS, the RAAF noted the considerable advantages in training its potential Ground Defence Officers at the Portsea facility.

RAAF Officer Cadet Roly Brazier became the first RAAF cadet at OCS in June 1956, starting a RAAF presence that lasted until December 1957. The first wave of RAAF cadets totaled nine graduates; after that, the RAAF elected to establish its own short course for ab-inito Ground Defence Officers to meet an immediate and sizeable shortfall in numbers. This short-term need perhaps justified the independent RAAF course, but both the cost and relatively small numbers soon resulted in the course becoming unsustainable. The RAAF re-established links with OCS for its Ground Defence Officer training, and the second wave of RAAF cadets started with Officer Cadet Robert Matthews in 1968.

By 1971 the category again reached its workforce strength ceiling and the RAAF presence at OCS ceased. However, by 1976 the strength of the Ground Defence category had once again been depleted and RAAF cadets, with Officer Cadet Ken Thackeray being the first, were again marching into OCS. The RAAF presence at OCS continued intermittently until Officer Cadet John Holloway graduated as the last RAAF cadet in December 1983.

The opening of the Australian Defence Force Academy (ADFA) in January 1986, led to RMC taking responsibility for non-tertiary, general service officer training for the Australian Regular Army. Army officer training was now provided by both ADFA and RMC, thus OCS's capacity was no longer needed and the school was closed in December 1985. All future RAAF Ground Defence Officers would be trained in RMC.

While all OCS cadets shared the same training, the careers of Army and RAAF graduates differed markedly. Initially, the RAAF considered that ground defence was not an enduring or viable career for most OCS graduates. The expectation was that after some years as a Ground Defence Officer, most would transfer to the then Administrative or Equipment branches of the RAAF officer corps. Officer Cadet Bob Halverson from the June 57 Class followed this path to become an Equipment Officer, while most others simply left the RAAF at the end of their engagement.

Rising regional tensions in the 1960's forced the RAAF to a more operationally focused stance that had a significant impact on the RAAF's OCS graduates. As the increased importance of ground defence became apparent, particularly with operational deployments to Thailand and South Vietnam, Ground Defence became an enduring element of the Special Duties Branch of the RAAF.

Demand for dedicated Ground Defence capabilities generated an increase in the number of officers required, a trend that has been noticeable at the end of each major combat deployment including Timor and the Middle East. Ground Defence Officers now served full careers in that category but for many years promotion above Wing Commander was generally not possible. Eventually recognition of the quality of OCS graduates broke the glass ceiling. Of the 30 RAAF cadets who graduated from OCS four retired as Group Captains (including Bob Halverson who became an Australian Senator and Ambassador to Ireland) and one as an Air Commodore.

The realities of an increasing operational tempo for the Australian Army from the 1950's onwards provided an unexpected opportunity for the RAAF's Ground Defence category to be maintained on a sustainable basis. With increasing Joint training models being adopted since the 1970s the OCS model is now a common feature across the ADF. Not only does common training prove cost effective, but ensures a common doctrinal and tactical understanding off the Joint operating environment–exemplified by the current Ground Defence Officer category.

# The Defence Restructure 1976 (#239)

> **Key Points**
>
> - *Post World War II the Defence organisation needed to be reformed to make it more efficient and responsive to Australia's security needs.*
> - *The 'Tange Report' recommended the most significant command change in the Air Force since formation.*
> - *The CAF is now sole commander responsible for the management and effectiveness of Australia's air power.*

As the ADF looks to its future in the wake of the First Principles Review, Force Structure Review and the imminent White Paper, it is worth looking back to the last major reorganisation of the ADF that took place in the wake of the 1973 Tange reforms. These reforms coined the term Australian Defence Force, enshrined the Defence Diarchy within Defence and consequently helped shape Australia's response to security challenges in the post-Vietnam era.

The tabling of *The Australian Defence: Report of the Reorganisation of the Defence Group of Departments* in federal parliament on 4 December 1973 was a watershed moment, bringing three distinct fighting forces into a single cohesive group capable of conducting a joint operation to meet national security objectives. Colloquially known as the "Tange Report", named after the author Sir Arthur Tange, then Secretary of the Department of Defence, the aim of the Report was to institute structural, strategic and economic changes to ensure that the three services could better serve Australia.

Its key recommendations included: the abolition of the three Service's departments and their respective Boards; consolidation of the administrative functions of the individual Services back into the Department of Defence; appointment of a single Minister responsible for all defence matters; appointment of a Minister Assisting; the creation of Chief of Defence Force Staff position; and amendments to the responsibilities of the Service chiefs.

Tange's recommendations sought to improve organisational structures that dated back to 13 November 1939, when, as a result of the increasing demands of World War II on the Australian Government, the Department of Defence was separated into smaller departments of Defence Co-ordination, Air, Army and Navy with new ministers and secretaries appointed for each. As a result each minister with encouragement from their respective Service Boards became increasing inwards focused, seeking a greater share of the defence budget.

Once the War concluded, there were calls by senior officers such as Air-Vice Marshal William Bostock to appoint a commander-in-chief with the authority to conduct joint operations, while others like the then Defence Secretary Sir Frederick Sheddon argued for a neutral official to balance out the demands from the services. Contrary to the lessons learned in the War, there was a level of resistance from within government and defence leaders to meld the three services into a more cohesive force.

Initial moves to merge the three Services, the Departments of Supply and of Defence Production into one large Department of Defence can be traced back to a Defence group review headed by Lieutenant-General Sir Leslie Moreshead in 1957. Only part of the Review Group's recommendations were accepted by the Menzies government — that of amalgamating Defence Production into Supply. The Government also issued an administrative directive creating the Chairmen of the Chiefs of Staff Committee (CCOSC) position to act as principle military adviser to the Defence Minister. This position had no command authority over the Services.

The next notable change was during Air Marshal (subsequently promoted to Air Chief Marshal) Sir Fredrick Scherger's term as CCOSC from May 1961 to May 1966. He consistently argued for a single "Australian Defence Force" of three fighting arms in lieu of independent services, under one Minister. However as the Vietnam War was gaining momentum he was reluctant to pursue this issue as he felt it would be a distraction to each service's ability to conduct its part in the War. When General Sir John Wilton succeeded Scherger, he also supported a single department but wanted to retain three distinct services. By 1972 both political parties of the Australian

Government recognised that amending the Defence structure was a matter of necessity.

Tange, a career public servant, was appointed as the Defence Secretary in March 1970 and recognised that action needed to be initiated to make the Defence group more efficient. In December 1972 the newly elected Lance Barnard took ministerial control of the five separate departments, Defence, Air, Army, Navy and Supply. Barnard requested that Tange complete a new White Paper on Defence. On 15 November 1973 Tange submitted the report to the Minister. The government accepted most of the recommendations and immediately began implementing them. Changes that could be effected without legislative amendment were commenced and on 30 November 1973, the three single service departments were abolished and placed under the jurisdiction of a single department and minister.

The *Defence Force Act 1903* was amended to change the CCOSC post to the Chief of Defence Force Staff (CDFS), (subsequently renamed Chief of the Defence Force (CDF) in 1984). The amendment made the position the statutory commander of the Australian Defence Force with the authority to appoint an officer from any service to lead a tri-service taskforce. The *Defence Force Reorganisation Act 1975* became law on 9 September 1975 and the main provisions of the Act took effect on 9 February 1976. From this date individual Service Boards were abolished and ministerial directives were issued to the Service Chiefs amending the chains-of-command and authority.

For Air Force, this was the biggest change in its command structure since its formation in 1921. The directive informed the Chief of the Air Staff (CAS, retitled to CAF in 1997) that the Air Board no longer commanded the Air Force, but that CAS had become solely responsible for command, management and effectiveness of Australia's air power. Accordingly the Air Board met for the last time on 30 January 1976 and a new advisory body, the Chief of the Air Staff Advisory Committee (CASAC) met for the first time 16 February. The CAS through this challenging period was Air Marshal James Rowland, (CAS March 1975 – March 1979 and Knighted in 1977), a decorated WWII Pathfinder pilot with Bomber Command, test pilot and engineer. Rowland was perhaps an ideal leader to guide the Air Force through this period of significant change.

As the revised Department of Defence now had a diarchy leadership, that of the CDFS and the Secretary, the Report also recommended that ministerial directives be issued to both parties to clarify duties and boundaries. The restructure did experience some push-back in its early phases of implementation and there followed a long period of continuous reform and fine tuning into the 21st century. Tange noted that the phrase “the Defence Force” within the *Defence Act* legislation was rarely mentioned–in a measure of the broad maturity and influence of the Tange reforms, today the term is in common usage.

## The Father of RAAF Radar: Air Commodore Alfred Pither, CBE (#252)

> **Key Points**
>
> - *Alfred Pither was a tireless advocate for the establishment of an RAAF radar network during World War II.*
> - *Over 150 ground-based, early-warning radars, and many mobile ground control intercept radars were central to his vision.*
> - *The fundamentals of the contemporary ABM role trace a direct lineage to the principles of fighter control established during World War II.*

Speaking on his experiences of air combat during the Battle of Britain, famed German fighter pilot Adolf Galland later recalled, ‘We learned very soon that English radar was just perfect, but we neglected to attack the system’. For the RAF, the network of radars and control rooms gave the British commanders the upper hand in the battle. Two years later, radar was instrumental in defeating the air threat to Allied forces in Northern Australia and the South West Pacific. This was the genesis of the Air Battle Management (ABM) process still practiced today and one in which a young RAAF officer, Alfred Pither, played a major role.

Born and raised in country Victoria in 1908, Alfred Pither had an abiding fascination for radio in his early years. In 1927, he was selected by the RAAF as one of the first cadets to attend the Army’s Royal Military College, Duntroon (RMC), before being commissioned into the Air Force. After graduating from RMC in 1930, Pither completed pilot training at Point Cook and after a short flying tour with No 1 Squadron, was posted as the Station Signals Officer at Point Cook. Further postings involving signals work in Air Force Headquarters and at Laverton gave Pither practical experience in this specialised field.

In 1936, he was promoted to Flight Lieutenant and sent to the UK to attend the Royal Air Force signals course at RAF Cranwell. On completion, he returned to be in charge of signals training at the

RAAF Signals School at Laverton. Pither's enthusiasm for the role was such that he designed a new training facility which was built at Point Cook. On 1 September 1939, Pither was promoted to Squadron Leader and posted to Air Force Headquarters in Melbourne, where he planned the expansion of the Air Force's signals training schools. A huge increase in the rate of this training was required if Australia was to achieve its commitment under the Empire Air Training Scheme. Pither's workload was immense, but the required outcomes were achieved.

In September 1940, Pither travelled to England where he witnessed first hand the benefits afforded by radio direction and ranging (radar) in the control of RAF fighters countering the Luftwaffe's bombing campaign. Promoted to Wing Commander on his return in 1941, Pither was posted to Air Force Headquarters where he was responsible for the development of the RAAF's radar capability. Recalling the techniques employed during the Battle of Britain, he developed a plan to surround Australia with a chain of radars consisting of nine 'Advanced Chain Overseas' radar stations using equipment imported from Britain.

With the Japanese entering the war in December, getting a radar network operational was a top priority. Under Pither's direction, 57 radar stations were built, equipped and manned, 100 aircraft were fitted with airborne radar, a radar school was created and over 1500 personnel were trained in the maintenance and operation of this specialised equipment. All this was achieved in only 18 months.

The personnel and equipment required to establish No 31 Radar Station at Dripstone Caves near Darwin arrived on 5 February 1942, but the system was still under construction when the first air raid occurred on 19 February. However, by March 1942, No 29 Radar Station with their early warning radar became operational at Port Moresby just in time to provide warnings and allow the Kittyhawks of No 75 Squadron to intercept the attacking Japanese bombers.

Pither also foresaw the need for mobility and drew up the requirement for an air-transportable radar. This resulted in the Light Weight Air Warning (LWAW) radar which was largely manufactured in Australia. In December 1942, No 50 Radar Station deployed with one of the first of these radars to Dobodura, PNG using six C-47 transport aircraft. Within days, the radar was operational and providing warning of the approach of enemy aircraft to Allied forces in the Buna campaign. Later in the conflict, No 114 Mobile Fighter Control Unit and their six subordinate radar stations equipped with LWAW radars, disembarked in the amphibious landings on Tarakan, Borneo in May 1945 and within days, assumed responsibility for the air defence of the beachhead.

Having achieved so much in establishing the radar early warning systems around the Australia, Pither was again sent to England in 1944. As a staff officer in the Allied Expeditionary Air Force Headquarters, he assisted in the planning of air defence measures necessary for the Normandy landings. From July 1944, he served with No 80 Wing RAF—a formation that was established to jam or 'bend' the radio signals used to guide German bombers to their targets. When German V-2 rockets began impacting British cities, it was believed that the missiles received some sort of radio guidance. A radio-countermeasures unit of No 80 Wing, commanded by Pither, deployed to France and Belgium in October 1944 in an unsuccessful attempt to jam the missiles shortly after launch.

Pither returned to Australia in December 1944, taking up the post of Director of Radar and continued his work developing the Air Force's radar capability. Shortly after the end of hostilities, he joined the Australian Scientific Mission to Japan which examined the state of Japanese scientific development. In 1947, he was promoted to Group Captain and assumed responsibility for the RAAF involvement in guided missile development. It was in this capacity that Pither was active in establishing a rocket-range in South Australia and is credited with suggesting the name 'Woomera' for the new establishment. In 1956, his service in the wartime Air Force was recognised when he was appointed a Commander of the Order of the British Empire (CBE).

Group Captain Pither's last decade of service was spent in various appointments that included Commanding Officer No 1 Aircraft Depot at Laverton, and Officer Commanding RAAF Laverton. From January 1963, he held the post of Staff Officer Telecommunication Engineering at Headquarters Support Command in Melbourne. He retired from the Air Force in February 1966 with the honorary rank of Air Commodore. Air Commodore Pither passed away suddenly in Melbourne in 1971 where he was cremated with military honours.

Today, Air Commodore Pither is remembered within the RAAF air defence community as the Father of RAAF Radar. His advocacy of radar systems pioneered the ISR networks of the contemporary Air Force. Every year, the award of the Pither Trophy to the airman making the most positive contribution in support of No. 41 Wing's activities, is a fitting tribute to this dedicated officer.

# RAAF Involvement In Nuclear Testing (#232)

Between 1952 and 1963 the British Government, with the agreement and support of the Australian Government, carried out nuclear tests at three sites in Australia—the Monte Bello Islands off the Western Australian coast, and at Emu Field and Maralinga in South Australia. This series of tests was designed to meet a technical and scientific requirement of the UK Ministry of Supply, in support of Britain's nuclear weapons program. As directed by the Australian government, the RAAF provided aircraft and personnel along with the other Services to support the British-led activities.

**Key Points**

- *The British government looked to Australia for suitable the RAAF responded quickly with the development of decontamination procedures for aircraft and equipment.*

Operation *Hurricane* was the first test conducted at Monte Bello Islands on 3 October 1952. To obtain atmospheric samples, five RAAF Lincoln aircraft from No 82 Wing, each fitted with four collecting canisters, conducted simultaneous flights across the probable path of the resultant cloud. Since there was no intimation of the possibility of any contamination taking place during the course of these flights, and because of the expectation that any exposure if at all, would be very low, no protective measures had been taken.

Five Dakota aircraft from No 86 Wing provided daily logistics support to Broome, and then to Onslow for security patrols, ferry flights and monitoring flights for radio-active fallout. Two of the Dakotas were fitted with ionisation chambers for radio-activity monitoring and carried a scientist on each sortie. Reports indicated that these flights showed no deposition of fission products on the mainland.

Even before Operation *Hurricane*, the need for a land test site had been realised and a suitable location selected at Emu Field. The desert terrain contained large expanses of sand dune and drift, but in places was quite hard enough to allow landings of large transport aircraft. It was from here that Operation *Totem* was conducted on 15 and 27 October 1953.

RAAF Lincoln aircraft of Nos 2 and 6 Squadron were employed on cloud tracking/sampling missions on 15 October. Two of the Lincolns also entered the cloud on 27 October. A RAF Canberra was especially assigned to fly through the atomic cloud immediately after the explosion, and two US B-29 aircraft operated out of Richmond on cloud tracking and sampling for both the tests.

Four Dakota aircraft of No 38 Squadron, each fitted with an ionisation chamber and accompanying scientist, were employed on air radiological surveys to determine ground contamination caused by fallout of radio-active dust.

At the conclusion of the operation, nine out of the 12 Lincolns were found to have been contaminated. Of these, eight required special decontamination procedures and ultimately four never flew again.

The RAAF had been led to believe there was minimal hazard to personnel and aircraft associated with sampling radioactive clouds, and needed to devise a quick response to this unexpected hazard. With the support of nuclear experts, the RAAF developed control, exposure management and decontamination procedures, and constructed specialised decontamination facilities. The experience gained from procedures developed at Emu Field, Woomera and Amberley contributed to the success of control procedures used during the later series of tests.

The next tests, named Operation *Mosaic*, were conducted on 16 May and 19 June 1956 at Monte Bello Islands. They were preliminary tests for Operation *Buffalo* to be conducted at Maralinga later in the year. In this case, RAF Canberra aircraft (including one crewed by RAAF members) were used to enter the clouds of both explosions, and three RAAF Neptune aircraft from No 11 Squadron were tasked for outward seaward security patrols, transport and observation. The USAF provided two C-118 (DC6) aircraft for the collection of radio-active samples. Partial decontamination of the aircraft was conducted at RAAF Base Pearce.

The move to Maralinga was brought about by concerns of nuclear fallout from the previous tests at Emu Field, its inadequate infrastructure and water supply, and the British government's formal request for a permanent facility which had been made in 1953. The new site was announced in May 1955 and developed as a joint, co-funded facility between the British and Australian governments.

Prior to selection, the Maralinga site was inhabited by the Pitjantjatjara and Yankunytjatjara aboriginal people. Many were relocated to a new settlement at Yulata, and attempts were made to curtail access to the Maralinga site. These attempts were often unsuccessful, as most indigenous people were unable to read the warning signs placed around the perimeter of the site.

The first tests at Maralinga, Operation *Buffalo*, were conducted over the dates 27 September, 4 October, 11 October and 22 October 1956. No RAAF aircraft participated but other support was provided. The RAAF coordinated air traffic control at both Edinburgh and Maralinga, provided ground personnel for the range construction force and armament and operational officers for the observation of handling, loading and arming of the atomic weapons. Aircraft decontamination was principally carried out at the Maralinga airfield, and to a lesser extent at RAAF Base Edinburgh.

The fallout from these tests was measured using sticky paper, air sampling devices, and water sampled from rainfall and reservoirs. The radioactive cloud from the first explosion exceeded the predicted height and radioactivity was detected in South Australia, Northern Territory, New South Wales, and Queensland. All four *Buffalo* tests were criticised by the 1985 McClelland Royal Commission, which concluded that they were fired under inappropriate conditions.

The following year, Operation *Antler* was conducted at Maralinga, with tests being carried out on 14 and 25 September, and 9 October 1957. The operation comprised the detonation of five explosive devices—three from towers and two from captive balloons. A fully armed Lincoln and aircrew from East Sale was placed on standby to shoot down the balloon with the explosive device attached in the event of any mishap occurring. Also, a Dakota from No 86 Wing undertook patrols for radio-active detection purposes after each explosion.

Although the *Antler* series of tests were better planned and organised than the earlier *Buffalo* series, intermediate fallout from one of the tests exceeded predictions. Also, one of the tests used cobalt pellets as a tracer for determining yield, and it was later found that personnel handling these pellets were exposed to the active cobalt 60. Decontamination of aircraft was now a British responsibility, and no RAAF personnel were involved. Up to this point, the British and Australian governments had relied on the RAAF for support through the provision of aircraft and personnel, which was critical to the success of the nuclear tests.

Following Operations *Buffalo* and *Antler*, there were a number of minor trials, assessment tests and experimental programs conducted at Maralinga until 1963, when the British Government decided that the site was no longer needed. A formal ban had been placed on atmospheric nuclear weapons tests, and as a result much of 1964 was spent cleaning up the site and burying the most contaminated equipment. In 1966, Britain decided to relinquish the site entirely and a more comprehensive decontamination program, Operation *Brumby*, was conducted. Maralinga was officially closed in 1967.

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# List of Contributors

Allan, Steve – 236, 239

Burns, SQNLDR Dave – 252

Dunn, Shane – 225

Frederickson, SQNLDR Lewis – 238, 252

Harvey, Hal – 233

James, Mr Martin – 218, 220, 222, 228, 230

Kainikara, Dr Sanu – 217, 219, 221, 223, 229, 231, 235, 237, 240, 242, 243, 245, 247, 249, 251

Lax, AIRCDRE Mark - 226, 246, 248

Meier, AIRCDRE John – 224, , 241, 244

Pearson, AIRCDRE Ian – 250

Ross, WGCDR Darren – 227

Turner, Ms Roz – 232, 234

# Index

# Index


463 L pallet 119

Afghanistan 7, 64, 114, 125
Afghanistan, operations in 126
AGM-84 Harpoon missile 115
air battle management 141
airborne early warning 25
Airborne Early Warning and Control 17, 49
Airbus A320-100 19
air combat 3
air combat capability 3
air combat platforms 3–6
air denial 48
air power 31–34, 35–38
  and military forces 43–46
  and national security 67–70
  and the information domain 59–62
  arrival of 44
  capabilities 63–66
  collateral damage 51–54
  flexibility 48
  long-range strike capability 48–50
  reach 48
  space 71–74
  speed 48
  strike capability 77–80, 81–84
  sustainability of 39–42
air power capabilities 31–34
airships 27–30
air superiority 18
air-to-surface munitions 5
Albatros DVa 102
anti submarine warfare 113
Anzac Day 115
ANZUS 114
Apache AH-64 E model 11
armoured personnel carrier 95
artificial intelligence 15, 16
Australian Air Corps 78
Australian Army 134
Australian Flying Corps 97–100, 101–104
  in New Guinea 105–108
Australian Naval and Military Expeditionary Force 105
Australian War Memorial 102
Autissier, Isabelle 115
automated aircraft systems 19–22
auto-pilot 21

B-2 Spirit 55
B-24 Consolidated Liberator 109–112
B-47B Stratojet 83
Baghdad 44, 99
Basrah 44
Bass Strait 114
Boeing F/A-18 79
bomber aircraft 77
Bomber Command 79
Bostock, Air-Vice Marshal William 138
Brazier, Officer Cadet Roly 135
Bristol Beaufort 78
Bristol Fighter 100
Bristol Sycamore helicopter 89
British Colonial Office 44
British Empire 44
British Third Army 102

C-47 Dakota 86
C-130A 117
C-130A training system 118

Canberra bomber 82–83
capabilities, air combat 3
casualty evacuation 93–95
Catalina 78
Central Flying School 98, 105, 107
centralised control and decentralised execution 125
Charters Towers 109
Chester, Richard 97
Churchill, Winston 44
Cierva C.30A autogyro 85–86
Cobby, Captain Arthur 'Harry' 103
collateral damage 16–17, 51–54, 57
combat, air 3
combat control 125–128
combat controller mustering 125
command and control 17, 61
Commonwealth Aircraft Corporation 121
Communication and Information Systems 60–61
concept of operations 60
CONOPS 60
control of the air 13, 18
counter-insurgency 23
counter-terrorism 23
critical mass 42
  definition of 35
critical mass and air power 35–38
cultural heritage 129–132

Dakota 118, 145
Dassault Mirage 79
Defence Force Act 1903 139
Defence Force Reorganisation Act 1975 139
Defence restructure 137–140
de Havilland Mosquito 78
Deptula, Lt Gen (Ret) 59–60
deterrence 31
Directed Energy Weapons (DEW) 5
doctrine 59
Dresden 129

electronic attack 8
electronic warfare 9, 25, 49
Elta ALR-2001 Electronic Support Measures 115
English Electric Canberra bomber 82
Ermolenko, Georgi 116
Exclusive Economic Zone 114

F-4E Phantom II 83
F-22 4
F-35 Lightning II Joint Strike Fighter (JSF) 4
F-111 83–84
F-111C 117
F/A-18 60
F/A-18F 84
Falklands War 70
fibre optics 6
fifth generation aircraft 3
fifth generation capability 3–6
First Principles Review 137
Five Power Defence Arrangements 114
Fonteneau, George 98
Force Structure Review 137
France 103

Global Positioning System 71
Gloucestershire 103
Granovetter, Mark 35
Ground Defence Officer 133
Gulf War 44, 52

Hague Convention 129
Half-Flight 107
Hamel, Battle of le 102
Harpoon missile 115
Harrison, Eric 97
Hawaii 113
Hawker P.1081 fighter aircraft 121
Heath, Cyril 98
high-altitude long-endurance (HALE) 25
HMAS Una 106
humanitarian aid and disaster relief 68
Humanitarian Assistanace and Disaster Relief 120
humanitarian assistance 51, 63–64
hybrid airship 27–30
hydrogen fuel 28
hypersonics 5

India, Government of 107
Indian Ocean 114
information domain 59–62
International Court of Justice 72
Iran 8
Iraq 7, 51, 53, 125
Iroquois helicopter 89–90, 94–96
Islamic State 53
ISR 9, 12, 23, 24, 27, 28, 32–33, 51, 114, 130
Israeli Defence Force 24
ISTAR 24

Java 79, 110
Joint Strike Fighter (JSF) 4

Kali Konto 79, 110
Kittyhawk 79
Kosovo 45

Law of Armed Conflict 52
Liability Convention 73
Liberator 109–112
Libya 45
lighter-than-air (LTA) airship 27–30
Lincoln bomber 82
loadmaster 118
Lockheed Hudson 78
Long Endurance Multi-Intelligence Vehicle (LEMV) 29–30
long-range strike 47–50
Long Tan, Battle of 91, 95
Low Earth Orbit (LEO) 72

Malayan Emergency 82, 119
Manwell, Lieutenant David 98
Maralinga 145, 147
Marshall Airways 87
medium-altitude long-endurance (MALE) 25
Mendalan 110
Mendalan hydroelectric power station 110–112
Merz, Lieutenant George 98
Mesopotamia Half Flight 101
Meteor 122
Mirage III 117
mission systems 8
mobile weapon systems 24
Monte Bello Islands 145
Moon Treaty 73
Moreshead, Sir Leslie 138
Mosul 44
multi-role platform 3
Mustang 79, 122

NASA 27
national security 63–66, 67–70
National Service 133

Navigation via Signals of Opportunity (NAVSOP) 71
New Guinea 105–108, 110
No 1 Squadron 99, 101
No 5 Squadron 94
No 7 Operational Training Unit 110
No 9 Squadron 94–95
Northrop Grumman 55
nuclear testing 145–148
Officer Cadet School 133–136
Operation *Antler* 147–148
Operation *Brumby* 148
Operation *Buffalo* 146–147
Operation *Estes* 114
Operation *Gateway* 114
Operation *Hurricane* 145
Operation *Iraqi Freedom* 60
Operation *Mosaic* 146
Operation *Protective Edge* 24
Operation *Solania* 114
Operation *Totem* 146
Orion (P-3) 113–116
Outer Space Treaty 73

P-2 Neptune 113
P-3 Orion 113–116
Pearce, Senator George 97
Pethebridge, Colonel Samuel 106
Petre, Henry 97
photovoltaic cells 28
pilot-fatigue 20
Pither, Commodore Alfred 141–144
Point Cook 107
power projection 47
precision 32–33
precision air strikes 32–33
Predator 60
Project Skyward 86
Project ZODIAC 60–62
pulse weapons 5

Rabaul 107
radar 6, 141–144
Radford-Collins Agreement 114
RE8 reconnaissance biplane 102
Registration Convention 73
Reid, Andrew Thyne 86
Reynolds, Lieutenant Colonel Edgar 99
Robertson, Squadron Leader Ken 88
robotic fighter aircraft 5
Rolls-Royce 82, 122
Roman Empire 44
Royal Aero Club 87
Royal Australian Air Force 103
Royal Flying Corps 98, 99, 103
Royal Military College, Duntroon 133, 141
Royal Naval Air Service 103
Royal Navy 44
RQ-170 Sentinel 8
rules of engagement 52
Rutherford, Lieutenant David 100

Sabre 122–123
Schelling, Thomas 35
Scott, FLTLT William 123–124
SEATO 119
Sepik River 106
Sheddon, Sir Frederick 138
Shorland, Ted 98
Sikorsky S.51 Dragonfly 85, 87, 89
Sikorsky Type R.5 87
Siman 110
Siman hydroelectric power station 110–112
Singapore 116

sixth generation air combat platform 3–6
smaller unmanned aerial systems. *See* unmanned aerial systems
South China Sea 8
South East Asian Treaty Organisation 90
South-West Pacific 114
South West Pacific Area 78, 109
space weaponisation 71–74
stealth aircraft 55
strategic bombing 55–58
stratospheric airship 27
strike 13, 109
strike capability 77, 77–80, 81–84
suppression of enemy air defences (SEAD) 12–13
Syria 53

Tange Report 137
Tropical Force 105–106
Truscott 112
Truscott airfield 110
Tupovlev TB-3 77
typhoid 107

UNESCO 129
uninhabited aerial vehicles 23–26, 29, 51
  airframes 25
  future developments 23–26
uninhabited combat aerial vehicle 15–18, 51
United Nations 72
United States Air Force 58
United States Army Air Force (USAAF) 109
unmanned aerial systems 23
  control of 13–14
  ethical issues of 12
unmanned Aerial Vehicles (UAVs) 7–10
unmanned aircraft systems 11–14
unmanned surveillance systems 11–14
US Air Force 55

V-2 rocket 143
Viceroy of India 99
Vickers Vimy 77
Victoria Cross 100
Vietnam War 45, 93–96
Vultee Vengeance 110
Wackett, Lawrence 121–123
Watt, CAPT Oswald 98
weaponisation of space 71–74
White, Captain Thomas 98
White, Sir Thomas 123
Williams, Lieutenant Richard 98
Wilton, General Sir John 138
Wirraway 122
Witu Island 107
World War I 77, 97, 100, 105
World War II 45, 52, 55, 78, 81, 109