AIR POWER STUDIES CENTRE

PAPER 59

October 1997

EVALUATING AIR BASE OPERABILITY: AN AUSTRALIAN PERSPECTIVE

By

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About the Author

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INTRODUCTION

During an observation patrol over the Western Front on 24 August 1914, Captain H.C. Jackson and his pilot, Lieutenant E.L. Gornan, of the Royal Flying Corps observed three parked German aircraft on an airfield outside Lessines. On passing over the parked aircraft, a bomb was dropped. Although no apparent damage was observed, the attack is significant in being one of the first recorded air attacks on an air base.[1] Air strategists were quick to recognise the value of air base attack as an effective instrument of war, typified by General Giulio Douhet's observation in 1921 that 'it is easier and more effective to destroy the enemy's aerial power by destroying his nests and eggs on the ground than to hunt his flying birds in the air'.[2] Although air power possesses many inherent strengths, it also has its limitations, the most significant being its dependence on air bases. Many of the world's air forces, including the Royal Australian Air Force (RAAF), recognise this dependence as a major centre of gravity in their doctrine.

The strength of an air force cannot be measured alone by the number or quality of aircraft or their crews. Instead, overall strength depends on the sum of a number of essential individual elements and the effectiveness of their interaction. These elements can include platforms, weapons, air bases, logistics, command, control, communications, information management and intelligence, people, training, morale, research, industrial support, and strategy, doctrine and plans. Elimination or degradation of any of these elements, therefore, reduces air power's effectiveness. Of all the elements, air bases play the most critical role for many of the other elements may be located at, or supported by, an air base. The ability of air bases to withstand attack and recover quickly to continue mission generation can be termed Air Base Operability (ABO). ABO can be viewed as one leg of a tripod also comprising aircraft and munitions, all supporting combat operations.[3] Should any leg be lost, combat operations collapse.

For small forces such as the Australian Defence Force (ADF), ABO has two vital implications: the ADF must expect its air bases to be targeted in any conflict and it must be capable of successfully attacking enemy air bases. Understanding ABO and how it is achieved identifies not only how best to protect ADF air bases but also how best to target enemy bases. The aim of this paper is to examine the impact of ABO, its requirements and how well the ADF is addressing it in terms of protection and attack. The paper will examine a brief history of ABO, air base characteristics, likely threats, the active and passive defence of bases, and alternatives. It will then evaluate how the RAAF is addressing the major issues, focussing on bases in the north as well as some limited discussion on remote sensor sites supporting air power. While the emphasis of the paper will be on protective measures, the principles developed can be applied in most cases to the planning and conduct of air base attacks.

[1] Kreis, John F., *Air Warfare and Air Base Air Defense*, Office of Air Force History, United States Air Force, Washington DC, 1988, p 5.
[2] Douhet, Giulio, *The Command of the Air*, Office of Air Force History, United States Air Force, Washington DC, 1983 (originally published 1921), pp 53-54.
[3] Boyles, LTCOL Joe, USAF and Mittelman, Capt Greg, USAF, 'Paradox of the Headless Horseman', *Airpower Journal*, Spring 1989, pp 30-31.

HISTORY OF AIR BASE OPERABILITY

1914-1945

At the start of World War I, air bases were relatively primitive unpaved areas for aircraft operation, supported by semi-permanent or permanent structures with rudimentary or non-existent protection. As air power increasingly influenced the war's progress, so its bases became targets. Winston Churchill, as First Lord of the Admiralty and among the early disciples of attacking air bases, encouraged the imaginative and daring attacks by aircraft of the Royal Naval Air Service on German Zeppelin airships in their hangars. Major General Hugh Trenchard, the commander of the Royal Flying Corps and another disciple, had more than a third of his Independent Air Force attacking German air bases by 1918.[4] While air bases of all sides were still rudimentary at the cessation of hostilities, they were better protected through such measures as Anti-Aircraft Artillery (AAA), camouflage, dispersal, and deception.

By World War II, technological improvements and doctrinal development had changed the nature of air bases and their defence. Attacks against air bases, for example, were an integral part of the blitzkrieg warfare waged by Germany. Much of Germany's successes during its offensives in Poland, the Low Countries, Russia and the Mediterranean, can be attributed to its attacks on the air bases of opposing nations. These nations, hampered in defence of their air bases by an absence of radar, poor coordination of fighter and AAA defences, and inadequate communications, paid a high penalty. After the fall of France in June 1940, German attacks against Britain's air bases during the Battle of Britain were less successful due to the Royal Air Force's (RAF) excellent command, control and communication system using radar detection to provide coordinated attacks by the limited number of fighters and AAA defences. Backing these active defences was the effective use of passive defences such as camouflage, dispersal, revetments, rapid airfield repair, satellite airfields and deception. Recognising the damage that sustained German attacks would cause to the RAF's bases, Churchill directed a deliberate stratagem that enticed the German leaders to switch their attacks to Britain's cities.[5]

As the war progressed in the European and Mediterranean theatres, ABO lessons learnt early in the war were refined. Although the German airborne assaults on airfields in Crete were successful, their high losses deterred any future use of this previously successful tactic. At Malta, extensive dispersals, revetments and underground hangars, combined with effective AAA and air defences, frustrated German and Italian attempts to subjugate the island by air attack. The campaign in North Africa saw the development of ground attacks on Axis airfields by the British Long Range Desert Group and Special Air Service (SAS) forces. This new dimension of air base attack destroyed 367 Axis aircraft between 1940 and 1943, as well as causing the Afrika Corps to withdraw troops from the front line to protect their airfields.[6] On the Eastern Front after suffering initial crippling aircraft losses on the ground, the Soviet air force developed a doctrine employing large numbers of airfields to overcome the German air base attacks. Over 8,000 new bases were built,

[4] Kreis, *Air Warfare and Air Base Air Defense*, p 21.
[5] *ibid.*, p 90.
[6] Vick, Alan, *Snakes in the Eagle's Nest: A History of Ground Attack on Air Bases*, RAND, 1995, p 57.

emphasising camouflage and deception more than active air defences for their protection. Sometimes, this doctrine failed as illustrated by the loss of 50 transiting United States (US) B-17 bombers to a German air attack on the Soviet air base at Poltava in 1944. Allied and German air bases, however, improved their AAA defences to the extent that attacks against them towards the war's end usually took a heavy toll of attacking aircraft.

In the China, Pacific and Burma theatres, air bases played a crucial role. Many RAAF squadrons were subjected early in the war to highly effective airfield attack by Japanese air and ground forces. Soon after assuming command of the US 5th Air Force, General George Kenney switched from the defensive air battles of his predecessor to a highly offensive campaign. While recognising the importance of air battles, Kenney also recognised the value of his own airfields for offensive action, particularly for operations aimed at destroying Japanese air assets on the ground. For these airfield attacks, Kenney had weapons and tactics developed to enhance the devastation. In one action against a large, highly defended concentration of Japanese aircraft at Wewak in New Guinea, for example, Kenney had two deceptive airfields constructed to draw Japanese attention from the real airfield being constructed to give his fighters sufficient range to escort a bomber force to Wewak. The ruse worked brilliantly, allowing the destruction of nearly 200 Japanese aircraft, mostly on the ground, for negligible US losses. Similar successful attacks followed on the Japanese airfields at Hollandia (now Biak), employing highly effective AAA suppression.[7]

The major strategic shift in the Pacific war was the diversion by General Macarthur's forces to capture only those enemy territories necessary to extend the reach of air power to the Japanese mainland. Carrier-based naval air power played a significant role in protecting and supporting sea and land units employed for seizing islands used as 'stepping stones' to Japan. New air bases developed as part of this strategy required constant mobility by operations and supporting personnel, as well as the repair or construction of new operating surfaces and facilities. Operating surfaces ranged from the short, rudimentary earth or grass fields still suitable for certain tactical aircraft to the long, compacted runways necessary for the B-29 strategic bombing force. This increased complexity of air power brought a corresponding increase in the number of operating and support personnel, air base services and facilities, and the airlift capacity for the necessary mobility.

Post 1945

By the end of World War II, the basis for the modern military base had emerged with its extensive paved areas, buildings, logistics support and other facilities to support a new generation of aircraft. At the start of the Korean War, air base primacy was again reaffirmed when United Nations (UN) air forces operating from secure air bases in Japan supported their ground forces in stemming the initial North Korean invasion. As the UN forces switched to the offensive, their air attacks began to target the North Korean air bases. Once again, proven defences such as the North Korean rapid airfield repair, camouflage, deception and AAA defences were highly effective, the latter destroying 550 UN aircraft. Although the UN air forces were prohibited from

[7] *ibid.*, p 68.

attacking the MiG-15 bases inside their Manchurian sanctuary after Chinese intervention, these same aircraft also refrained from attacking UN air bases.

In Vietnam, the air war partly mirrored the Korean experience with US air attacks against North Vietnamese air bases, drawing no retaliatory air attacks by the North Vietnamese against US air bases in the south and Thailand. Excellent passive defences by the North Vietnamese including dispersal and hardening, combined with US political constraints, frustrated the US attacks. Even with the improvements resulting from the introduction of precision guided munitions (PGM) and the removal of political constraints, continuous strikes were required to counter rapid airfield repair. Fierce opposition was encountered from an air defence system assessed later by the US Air Force (USAF) as 'one of the best defence systems in existence', with AAA as well as surface-to-air missiles (SAM) surprising the attackers with their lethality.[8] Ground attacks against US bases by Viet Cong and North Vietnamese Army forces were both plentiful and successful. Between 1964 and 1973, 475 attacks, mostly conducted at night, destroyed 99 US and South Vietnamese aircraft, and damaged another 1,170. Some of the initial losses were due to poor dispersal, and the inadequate protection of aircraft against stand-off and penetration attacks. Layered defences were eventually developed using well equipped, mobile ground forces, supported by artillery, close air support and passive defence measures. Despite the aircraft destroyed, the attacks did not materially affect the outcome of the war due mainly to the operations by the higher value aircraft being unaffected.[9]

In the Middle East, Arab air forces suffered a stunning blow in the 1967 war, losing some 450 aircraft on the ground to highly coordinated surprise attacks by the Israeli Air Force. In the 1973 war, the Israeli Air Force was able to destroy only 22 Arab aircraft on the ground due to Arab forces gaining the advantage through launching the surprise attack, improved Arab airfield defences and hardened facilities, and the greater focus by the Israelis on supporting their own ground forces.

After 1973, a variety of ground attacks occurred against airfields in various conflicts. In 1981, Puerto Rican nationalists penetrated an Air National Guard base at San Juan, destroying eight A-7D Corsairs and damaging two. A year later, guerrillas in El Salvador destroyed 15 aircraft while British SAS forces in the Falkland Islands destroyed 11 Argentine aircraft, a radar unit and ammunition. In 1986, Afghan guerrillas destroyed three Soviet aircraft, including one shot down on approach to the Shindad air base by a shoulder-fired SAM. Other air base attacks this decade have occurred in the Philippines, El Salvador and Puerto Rico, but the most significant by far were those conducted by Coalition air forces during the Gulf War.[10]

Despite the qualitative and quantitative superiority of the Coalition air forces, Iraq's air bases provided some of the most formidable targets in the history of air base attack. Built almost as fortifications and regarded as the strongest element of Iraqi Air Force, its 66 air bases incorporated the best in survivability features for continued functioning in conventional, nuclear, chemical and biological wars. Measures included nearly 594 hardened aircraft bunkers, 'superhardened' facilities, redundancy,

[8] Kreis, *Air Warfare and Air Base Air Defense*, pp 278-298.
[9] Vick, *Snakes in the Eagle's Nest: A History of Ground Attack on Air Bases*, p 68.
[10] *ibid*., pp 11-20.

deception and well-trained rapid repair teams. The Coalition's campaign against the air bases began with their isolation through destruction of command and control facilities, followed by attacks on runways, hardened aircraft bunkers and support facilities. While the isolation attacks were successful, runway attacks proved costly, failing to hamper the limited Iraqi sortie rate, or to counter the pavement repair teams and their stockpiles. Despite the Iraqis' attempts to clear mines and sub-munitions aerially dispensed as part of these attacks, constant reseeding of these munitions may well have overwhelmed the Iraqi explosive ordnance disposal teams. Other attacks were more effective, with 375 hardened aircraft bunkers sheltering 141 Iraqi aircraft plus 50 per cent of maintenance facilities being destroyed. All of these attacks, however, were not sufficient to prevent the escape to Iran of 137 Iraqi front-line aircraft.[11]

AIR BASE CHARACTERISTICS

History, technology and economics have shaped the characteristics of the modern air base. With the exception of Vertical or Short Take-Off and Landing (V/STOL) aircraft, most modern high performance aircraft require extensive paved areas, support facilities and large numbers of support personnel for effective operation. Military air bases and civil air bases share many common characteristics driven by technological and economic needs, particularly operating efficiency. But the survivabilty needs of the military air base, arising from historical lessons and projected threats, create characteristics that can be paradoxical to operating efficiency. Meeting survivability needs, as well as the technological needs, can create air base areas with perimeters ranging from 6 to 60 kilometres. Even bare bases using deployed and mobile resources are large due to the size of their permanent fixtures such as runways. Examining the characteristics of military air bases, therefore, is a useful start in identifying their vulnerabilities and how these can be best protected or attacked.

Air Base Role, Functions and Organisation

The role of air bases is to generate and to recover missions for the application of air power, serving both as springboards for operations and as platforms for training the operational force.[12] To achieve this role, air bases perform a variety of enabling functions, most of which will be generic to any air base and some which will be specialised, depending on the missions conducted. Bases generating control of the air and strike missions, for example, will incorporate functions for storing and handling munitions while bases generating airlift missions will incorporate functions for storage and materials handling. For small forces such as the ADF, air base design must incorporate versatility to allow the performance of multiple roles, including use by the other services and allies. In addition, air bases may support transiting ADF or allied units, or geographically remote units such as radar sites.

[11] Centner, Christopher M., 'Ignorance Is Bliss: The Big Lesson from Desert Storm Air Base Attacks', *Airpower Journal*, Winter 1992, pp 25-35.
[12] AAP 1000, *The Air Power Manual*, Second Edition 1994, RAAF Air Power Studies Centre, p 62.

The functions performed by most air bases can be grouped under three major classifications: operations support, logistics and administration. Operations support functions can include air traffic control, air defence, ground defence and security, command, control and communications, photographic, and firefighting and rescue services. Logistics functions can include maintenance, flight line and air movements, warehousing and provisioning, motor transport, facilities, catering, and accommodation services. Administration functions can include personnel, resource and financial management, health, training, and executive services. Optimising the delivery of these services for both peace and conflict is imperative for reducing base operating costs, the number of supporting personnel, the level of resupply required for bases in an Area of Operations (AO), and the response times for recovering from the effects of attack. But the demands of peace and conflict can be opposing. Efficiency measures that reduce operating costs for peace can also reduce the number of personnel available during conflict for augmentation tasks such as air base defence and recovery. Organisational design for air base support, therefore, must address the component tasks comprising functions, the efficiency of processes, the multi-skilling of support staff to perform support and combat tasks, and the measures to ensure that augmentation requirements can be satisfied.

Air forces around the world vary in the way they organise air bases. Forces such as the USAF are large enough to dedicate some bases to specific aircraft roles such that a squadron or a wing deploying from its home base takes part or most of the air base support unit. While most overseas air forces that deploy do so to bases with established support, the RAAF strategy, for deployments and contingencies, is to employ mainly bare bases in the north of Australia, having a minimum of fixed facilities and no permanent support personnel. Activation of these bare bases requires the deployment of support personnel, prior to the arrival of deployed aircraft and other operational support from either one or a number of units. As the number of personnel required to deploy from a single base support unit to activate a bare base for a major deployment would be so large as to leave inadequate residual support at the main support base, the deployment requirement generally is shared by support units from a number of bases.

Air Base Types

The role and functions of an air base determine its design features. Generally, the term ‘air base’ conjures up visions of vast paved surfaces and extensive facilities. Such images ignore the realities of history, the needs of the various types of platforms, the conduct of operations, the need for flexibility, and the various demands placed by conflicts in which the ADF may become involved. Depending on these factors, air bases can be classified according to the following permanency levels of their facilities and personnel:

Permanent Operating Bases. Permanent operating bases are air bases with permanent paved movement areas, permanent facilities and permanent staff to perform all the generic air base functions. Increasingly referred to as ‘Main Support Bases’ by the RAAF, Australian examples are the bases at Tindal and Amberley.

Semi-Permanent Operating Bases. Semi-permanent operating bases are those with permanent paved areas, minimum permanent facilities and no permanent personnel,

apart from caretaking staff. Semi-permanent operating bases can be either service or civilian airfields capable of being activated using allocated staff and the necessary resources. Learmonth, Curtin and Scherger are Service examples, known as 'bare bases', while Karratha and Rockhampton are civil examples.

Temporary Operating Bases. Temporary operating bases are bases without permanent paved areas, facilities or personnel. Such bases are usually established in the field and employ transportable facilities including, where necessary, surface matting such as pierced steel or aluminium planking to strengthen operating surfaces. Temporary operating bases usually are suitable for use only by V/STOL aircraft such as helicopters, CC08 Caribous and C-130 Hercules.

Key Vulnerabilities

Destruction of, or damage to, air base facilities can affect the conduct of air operations according to the importance of each facility's function. For example, destroying unprotected fuel facilities may stop air operations more easily than destroying aircraft, runways or other essential facilities. By studying the function and characteristics of key air base facilities, analysis can be done on vulnerabilities to determine the best methods of protecting friendly air bases and attacking enemy air bases. The key facilities for study are the main operating surfaces, fuel installations, munitions areas, logistics installations, command and control centres, sensor, navigation and communication installations, personnel accommodation areas, and utilities.

Main Operating Surfaces. The major main operating surfaces are the runway, of which there can be more than one, and secondary runways depending on the size, location and role of the base. Other main operating surfaces are the taxiways, aircraft dispersal sites, operational preparation sites and maintenance sites; for some aircraft, hardened aircraft bunkers can perform the function of the latter three sites. Separate sites can be interconnected by taxiways and these in turn can connect to runways. Taxiways by design and construction may also serve the purpose of auxiliary or emergency runways, as may road surfaces inside or outside the base. The composition of these surfaces can include reinforced concrete, concrete, asphalt, paving blocks, stabilised earth or pierced metal planking. These surfaces can cover overlays consisting of compacted earth, rocks, gravel or sand. How paved areas are constructed determines the weapons necessary to damage them, the type of damage caused and the methods of repair.

Fuel Installations. Fuel installations consist of storage tanks and the plumbing to outlets. Storage can be either portable, such as large bladders inside bunds or berms, or permanent such as metal storage tanks. As bladders are normally surface mounted and exposed to attacks, they should be considered only for temporary operating bases where mobility is a necessity; however, they may serve as a quick, cheap option for the dispersal of fuel storage. While the siting of permanent tanks above ground at a central location reduces installation and operating costs, it increases their vulnerability to attack. Tanks, therefore, should be underground and dispersed to reduce their vulnerability. Fuel can be conveyed to aircraft refuelling sites either by pipeline or by tanker vehicles. As these vehicles also can become vital targets, they too require protection from attack.

Munitions Areas. Munitions require sites for storage, preparation and loading onto platforms. As detonation at any of these sites from either accidents or attack can lead to further sympathetic detonations of munitions at other sites, they require separation and protection either by hardened shelters or at least revetments.

Logistics Areas. Logistics areas are usually workshops and storage buildings which can be permanent, transportable or tented. Some of these areas may contain vital equipment such as automatic test equipment for the maintenance and repair of aircraft systems critical for mission success. Such critical equipment items and spares should have hardened protection, be dispersed or both.

Command and Control Centres. Command and control centres are critical for air base defence coordination, mission planning, and the conduct of air operations. As their loss would impact critically on base operations and defence, they are usually hardened, sunken and covered with protective layers of materials. Also critical for the operation of command and control centres are the information systems which must be protected against information attack.

Navigation, Sensor and Communications Sites. Permanent operating bases generally employ fixed navigation, sensor and communications systems, while semi-permanent operating bases employ both fixed and deployable systems. Siting of these systems will usually depend on their function, making it difficult to rationalise their location for protective purposes or to shift regularly to confuse enemy targeting. As the function, siting and construction of these systems make it difficult to reduce their vulnerability to attack, rapid repair or redundancy procedures must be incorporated into contingency planning.

Personnel Accommodation. Personnel accommodation likely to be attacked must provide some level of protection, especially from ground attack. Permanent buildings should provide protection such as reinforced walls to a height at least above bed level, with entry and exit points being protected from possible targeting. As aircrew could expect to be the highest priority targets amongst base personnel, protection of their accommodation and transit to their aircraft is vital.

Utilities. Most air bases depend on the civil infrastructure for the supply of utilities such as electricity, water and some telecommunications. As disruption or interference with any, or all, of these utilities can seriously affect base operations, measures must be taken to protect them and to provide redundancy, such as emergency generators and water storage.

THREAT TO AIR BASES

Threats to air bases arise from a number of sources. Direct sources can include air or ground attacks while indirect attacks can include surveillance or reconnaissance to gather information, either in support of a direct attack against the base or on operations being conducted. Another form of indirect attack is isolation by severing or interfering with three major base dependencies: the supply of utilities such as electricity and water, the main supply routes used for transporting supplies such as food, munitions and spare parts, and base communications. Special forces (SF)

recognise that air bases are but one component of a complete target system supporting the conduct of air operations and this system may be disrupted by severing vital components.[13] Information attack has only recently been recognised as a form of attack designed to target the dependency on information systems by modern armed forces. The final forms of threat particularly relevant to Australia's northern air bases are the effects of natural phenomena such as floods, bushfires and cyclones. All of these threats need examination to determine the best forms of countering and protection.

Surveillance and Reconnaissance

Surveillance and reconnaissance of air bases may involve ground, air or space based operations. Ground-based surveillance is most likely to be performed by SF elements using organic collection methods such as passive optical, electro-optical or infra-red devices for visual monitoring of operations, possibly supported by relayed collection of electronic activity. Air reconnaissance platforms may be manned or unmanned, with the use of Unmanned Aerial Vehicles (UAV) increasing in popularity due to the potential lethality in the airspace over well defended air bases. This danger makes satellite surveillance increasingly popular but their high costs are a limitation. But with satellite costs constantly reducing and the accessibility to commercial imagery increasing, their use is more likely in the future.[14]

Air Attack

The historical background of airfield attacks indicates that attack from the air is the most devastating. In the Gulf War, for example, air attacks of air bases were the primary means by which the Coalition air forces defeated the Iraqi Air Force.[15] Improvements in air base passive and anti-air (AA) ground defences, however, also have made airfield attack more dangerous to the attacker, assuming there has been successful penetration of the defending fighter screens. These improvements have made multiple attack passes by individual aircraft highly dangerous, forcing the development of specialised weapons to increase the effects of single passes or to allow stand-off delivery. Major targets sought during an attack usually are aircraft on the ground, main operating surfaces, command, control and communication facilities, and logistics support facilities such as fuel storage and aircraft maintenance facilities.

Targeting priorities in air base attack will depend on the results of a vulnerability analysis. An air base that has considerable redundancy in the layout and construction of its main operating surfaces, such as those in Iraq, may require more force than available to an attacker. This may shift attacks to aircraft dispersed on the ground, especially if these are not protected by hardened aircraft bunkers. How aircraft are dispersed and protected, and how paved surfaces are designed and constructed, will determine the weapons used. Weapons used for air base attack can be extensive, according to the target characteristics, their price and availability from manufacturers, the accuracy sought, and the price an attacker is prepared to pay in terms of risk to platforms. Weapons used for airfield attack vary significantly according to their

[13] DI(AF) OPS 5-3, *RAAF Ground Defence Policy*, 24 Sep 96, p 2.
[14] Sweetman, Bill, 'Spy Satellites: the Next Leap Forward', *Janes International Defence Review 1/1997*, pp 26-32.
[15] Centner, 'Ignorance Is Bliss: The Big Lesson from Desert Storm Air Base Attacks', pp 25-35.

country of origin but most share common features. While biological and chemical warfare weapons will not be discussed in detail, their possible use as 'the poor country's nuclear weapon' cannot be discounted when considering personnel protective measures, as again shown in the Gulf War. While the range of weapons is extensive, only a cross-section will be considered to understand the forms and effects of attack.

Bombs. Unguided free-fall weapons such as the Mk 82 (227 kg), Mk 83 (454 kg) and Mk 84 (908 kg) low drag, general purpose bombs offer the cheapest form of attack but require considerable skill to attain the necessary accuracy, while also exposing the attacking aircraft to the brunt of air and ground defences. A limited stand-off capability can be gained through the use of Paveway kits, or their equivalent, which use wing units linked to laser guidance to give almost pinpoint accuracy. Addition of larger wings to the Paveway type kits, such as that being developed under the Australian Defence Science and Technology Organisation's (DSTO) Project Kerkanya, or propulsion units such as on the AGM-123 Skipper, further increase stand-off capability. Similar accuracy and stand-off capability, without the need for an aircraft to laser designate the target, can be achieved by using the GBU-15 kit which employs TV or Infra-Red (IR) guidance, data-linked to the guidance operator in the attacking aircraft. The latest addition to enhancing the use of guided glide bombs is the replacement of laser, TV or IR seekers with Global Positioning System (GPS) guidance. GPS-aided munitions (GAM) are suitable for short fall times but longer fall times require the addition of inertial navigation units, such as incorporated in the Joint Direct Attack Munition (JDAM). Penetration of hardened targets can be enhanced by adding special units, such as the BLU-109 which is similar in shape and size to the Mk 84 bomb. Programs such as the US Miniaturised Munitions Technology Development (MMTD) promise lighter weapons with an early development of a 112.5 kg 'smart bomb' being able to attack 85 per cent of targets currently requiring the present 454 kg Mk 83 bomb.[16] Another example, but focused on allowing light combat aircraft to carry lightweight directed energy weapons capable of penetrating hardened structures such as aircraft bunkers, is the Bomb Royal Ordnance Augmented Charge (BROACH) system being developed in the UK.[17]

Airfield Denial Weapons. A range of weapons has been produced specifically for airfield attack and area denial. The simplest is the Matra SA Durandel penetration bomb which employs parachute retardation to allow a rocket motor to propel the bomb into runways or bunkers at the optimum penetration angle. Detonation can occur within seconds or hours, producing a crater two to three metres deep with heave effects.[18] For area denial and destruction of soft targets such as aircraft, vehicles and workshops, cluster bomb weapons such as the BL 755 system are highly effective. The 147 bomblets within this weapon employ shaped charges for penetration, as well as a fragmentation capability against non-armoured targets and personnel. Similar weapons such as the CBU-87 achieve similar effects and include incendiary sub-munitions. Both runway penetration and area denial can be achieved using the Hunting JP-233 aircraft sub-munition dispenser which incorporates 30 SG 357 runway penetration bomblets and 215 HB 876 mines; the latter employ explosive

[16] Devers, Stacey, 'Mini-bomb Packs Punch of Heavyweight', *Jane's Defence Weekly*, 24 July 1996, p 5.
[17] Price, Dr Alfred, 'Airfield Attack', *Air International*, June 1997, p 381.
[18] *Jane's Air Launched Weapons*, Issue 23, February 1996.

devices which make their clearance highly lethal to inadequately equipped and trained repair teams.

Air-to-Surface Missiles (ASM). Greater stand-off capability can be achieved through the use of ASMs but at a greater cost. Missiles range in types such as the short range AGM-65 Maverick with a range up to 25 km, to the medium range AGM-142 Popeye with a range up to 80 km. Representing a new family of ASMs are the variants of the Apache weapon being developed by France, Germany and Great Britain, and the US family of AGM-84 Stand-off Land Attack Missiles (SLAM). Variants have ranges from 140 kilometres to 600 kilometres with payloads ranging from unitary penetration warheads to sub-munition dispensers for runway and area denial. The development of lighter but more destructive explosives, combined with cheaper, more accurate terminal guidance provided by GPS, will make expensive stand-off weapons a more cost-effective option for the future. Particularly, the development of multiple warheads using GPS guidance to destroy critical, fixed targets such as aircraft, hardened aircraft bunkers and fuel storage will pose a significant and affordable capability. Combining this capability with the longer range of the cruise missile may well justify the latter's higher cost when evaluating them as a potential weapon for attacking high value air base targets.

Non-Lethal Weapons. Non-lethal weapons are 'discriminate weapons that are explicitly designed and employed so as to incapacitate personnel or materiel, while minimising fatalities'.[19] While the employment of non-lethal weapons to date has been limited, an increasing aversion to casualties, combined with the considerable array of weapons now available, identifies them as a potential consideration by the ADF for attack against, and protection of, air bases. Weapons include low energy lasers, computer viruses, high power microwaves, electro-magnetic pulse generators, liquid metal embrittlement, superlubricants, superadhesives, combustion alteration technologies, and electrical power alteration technologies. During the Gulf War, for example, computer viruses were used by the US to disrupt the Iraqi computer support to their air defence system while US cruise missiles dropped lengths of light, carbon fibres which landed on Iraqi electricity transmission lines, causing massive short circuits. An example of a simple but effective non-lethal attack against an air base could be the insertion of combustion alteration materials into aircraft fuel storage supplies.

Ground Attack

While air attacks employ relatively complex weapons, ground attacks by small forces using less complex weapons have damaged or destroyed over 2,000 aircraft in conflicts since 1942. Ground attacks can be in the form of either stand-off attacks from outside the air base boundary or penetration attacks within the boundary. In a study of 645 ground attacks recorded against air bases between 1942 and 1992, 41 were to capture the airfield, 47 were to deny the use of the airfield, 173 were to harass defenders, and 384 were to destroy aircraft and equipment. Seventy-five per cent of these attacks used stand-off weapons and also proved the most difficult to counter.[20]

[19] Casagrande, WGCDR E.E., *Non-Lethal Weapons: Implications for the RAAF*, RAAF Air Power Studies Centre, Canberra, November 1995, p 6.
[20] Vick, *Snakes in the Eagle's Nest: A History of Ground Attack on Air Bases*, Summary, p xx.

While air bases must be structured to counter penetration attacks, an emphasis on countering the stand-off attack not only addresses the most probable threat but also contributes to the prevention of penetration attacks.

The size, value and degree of defence associated with air base targets requires the employment of highly trained ground forces, such as SF, for attacks to be successful. Weapons likely to be applied by such groups vary according to the operational context but are likely to include direct fire weapons against individual assets or indirect fire weapons against area targets. Most dangerous of the direct fire weapons are portable SAMs employed against aircraft departing or approaching runways. While all aircraft during approach and departure phases will be particularly vulnerable, it is the high value targets such as Airborne Early Warning and Control (AEW&C), tanker and transport aircraft that especially may be targeted. Other direct fire weapons include anti-materiel weapons, such as large calibre automatic weapons and sniper rifles capable of penetrating aircraft, buildings and equipment at ranges up to two kilometres, and anti-tank rockets capable of penetrating many of the hardened targets on air bases.

Although less portable and less effective than direct fire weapons, indirect fire weapons such as mortars and rockets with ranges of up to ten kilometres can be effective against area targets and personnel.[21] Even bases outside the AO will need to exercise caution against covert attacks using these weapons. If mortars can be fired by the Irish Republican Army in the centre of London, then the possibility exists that they can be fired by covert forces at air bases outside the AO.

Information Attack

Modern air forces are becoming increasingly dependent on information systems for providing operational, logistics and administrative support. Military Information Operations (MIO) are those activities which consciously target or protect 'any element of an information system in pursuit of military objectives'.[22] Military information operations can be conducted using command and control warfare, computer operations, information weapons, or various combinations of these. The effects produced can be the disruption, the disclosure, the corruption or the destruction of information vital to air base operations. Air bases are highly dependent on information systems for the conduct of operations, protection measures, communications with external headquarters and resupply arrangements. Similarly, operations centres or headquarters located on an air base generally will be dependent on information systems as part of their links with external sensors. Information attack, therefore, is an essential consideration for the protection and attack of air bases.

Natural Hazards

The threat offered by natural phenomena such as bushfires, floods and cyclones cannot be dismissed. Since the birth of military aviation, cyclones, typhoons and tornados have destroyed aircraft and facilities at air bases across the world, including

[21] AAP 4130.001, *Ground Defence*, Section 1, Chapter 1, pp-1-4.
[22] Westwood, Chris, *The Future is not what it used to be: Conflict in the Information Age*, RAAF Air Power Studies Centre, Canberra, 1997, p 6.

the RAAF bases at Townsville and Darwin. During the US presence in the Philippines, the significant damage to Clark Air Force Base caused by the eruption of Mount Pinetabo was minimised only by the early evacuation of aircraft and personnel. Flooding in Bangladesh recently inundated a military airfield while floods in 1974 almost severed surface communications with the RAAF's base at Amberley. While the occurrence of natural hazards cannot be prevented, their effects can be minimised by early warning, a proven emergency response system, evacuation to alternate operating bases, good air base design and protective structural integrity of facilities.

ACTIVE DEFENCE OF AIR BASES

The active defence of air bases must be structured to counter both air attack and ground attack, plus the surveillance and reconnaissance associated with such attacks. Defences against air and ground attack must be coordinated so that attack in one form does not completely distract base defences from countering the other form. The sheer size of most air bases, combined with the variety of potential threats, makes air base defence a costly, complex and difficult task.

Air Defence

Defences against air attack on air bases will be projected in the air and from the ground. The key to these defences being successful is an effective and efficient command and control system. At the operational level, the overall coordination and direction of defences is exercised by a Joint Commander through a Joint Air Component Commander who also acts as a theatre air defence commander. The theatre air defence commander establishes an Air Defence Operations Area (ADOA) according to a campaign air defence plan. Joint Force Areas of Operations (JFAO) may be established within a theatre under Joint Force Commanders with Joint Force Air Component Commanders being responsible for air defences within each JFAO. A Joint Force Air Component Commander employs a Joint Force Air Operations Centre (JFAOC) to control air operations in the JFAO by processing information collected from a variety of land, sea and air based elements. Overall, the purpose of the JFAOC and its elements is to engage enemy aircraft and allow the safe transit of friendly aircraft, generally using a Tactical Air Operations Centre (TAOC).[23] In some cases, a JFAOC or some of its elements, such as a control and reporting post or a control and reporting centre, may be located on, or in close proximity to, an air base.

To prevent damage to its most valuable assets, the JFAOC will aim to intercept air attacks on air bases as early as possible, but at least before any aircraft carrying ASMs can launch their weapons. With the increasing range of stand-off weapons, this task is becoming correspondingly more difficult. Any enemy aircraft, ASMs or cruise missiles avoiding air interception then become the responsibility of ground-based air defence elements. These elements may employ a variety of weapons, such as SAMs and AAA. Depending on the defence force, these assets would be under the control of an air defence command post linked to the TAOC. As this post is usually sited where it can best communicate with its weapons systems, it is most likely to reside on, or in close proximity to, the air base. Maintaining communications at all times with

[23] ADFP 13, *Air Defence and Airspace Control*, Chap 3.

ground-based air defence systems is vital to prevent the fratricide of friendly aircraft operating from the air base.

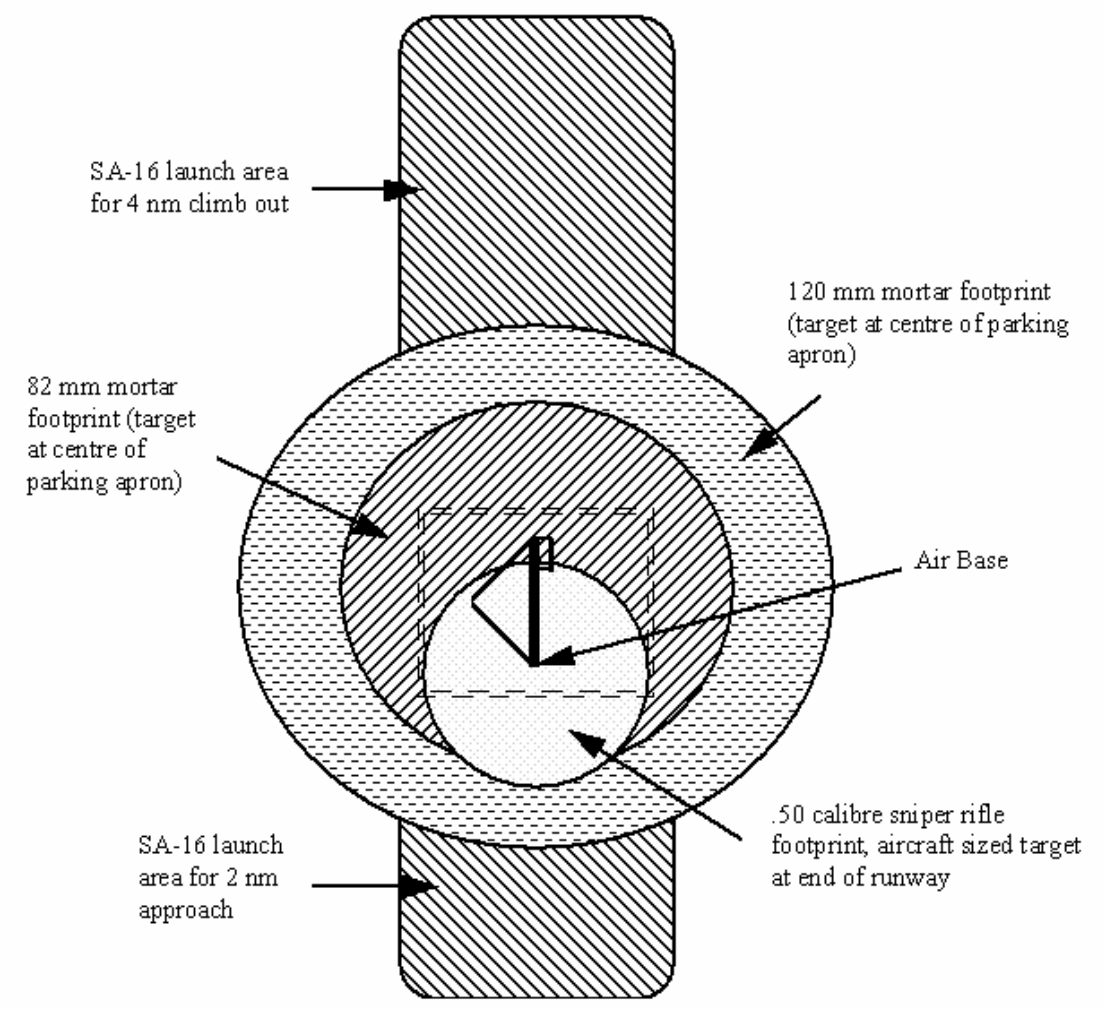

Figure 1 - Notional Threat Stand-off Footprints

Ground Defence

The objectives of air base ground defence will be premised on the nature of the threat and the perceived likely targets. Paramount amongst these objectives will be the prevention of enemy weapons being deployed against the base, and the denial of opportunities to observe and to report air base operations. As a minimum, this involves the defence of areas around the air base perimeter, areas under departure and approach paths, and the areas immediately surrounding potential vital targets. The production of a ground defence plan, in accordance with the ground defence

objectives, requires the identification and mapping of the following three areas and as shown in Figure 1:[24]

a. ***Patrol and Surveillance Area (PSA)*** encompassing a stand-off footprint based on the ranges of potential enemy ground weapons, approach and departure paths for friendly aircraft, and potential enemy observation posts;

b. ***Close Approach Area (CAA)*** encompassing a radius of one to two kilometres from potential key targets and main operating surfaces, as well as approach and departure corridors likely to be used by enemy raiding teams; and

c. ***Close Defence Area (CDA)*** encompassing a radius of at least 100 m beyond the defensive perimeter of key points.

Most modern air bases have a large CAA, while the dispersal of key assets such as aircraft, fuel and munitions, generates a large number of CDAs. Combining these CDAs and CAA with the PSA required for the protection of aircraft approach and departure paths (which may extend up to 40 kilometres off the end of runways) from SAM threats, plus the denial of any observation points on any high ground in proximity to an air base, produces an enormous ground defence task. Historical evidence shows that aircraft and air bases affected by ground attack have seldom had an adequate ground defence. While the ground defence of air bases has generally been an land force responsibility, historical evidence indicates that the demands on army resources in most conflicts seldom allow the allocation of resources adequate for air base defences. Some air forces have overcome this problem through developing their own organic ground defence forces such as the USAF's Security Police, the RAF's Regiment and the RAAF's Airfield Defence Squadrons. Even these organic forces are seldom sufficient, often requiring further augmentation by other air base support staff trained for ground combat roles.

Basic air base ground defence doctrine varies among different air forces, producing corresponding variations in the responsibilities, organisation, concept of operations and equipment of the ground defence forces. Ideally, responsibility may be given to army forces for the PSA, to organic ground defence forces for the CAA and to augmentation forces for the CDAs. Contingency planning, however, should include the possibility of the organic ground defence forces having to take a major responsibility for most, or all, of the PSA. To defend these large areas, air base ground defence forces require key capabilities such as information superiority, rapid mobility, precision engagement and precision attack. Information superiority can be attained through a comprehensive military and geographic information system, and an effective command, control, communications, intelligence, surveillance and reconnaissance system. Linked to information superiority is precision engagement which can be achieved through the employment of sensors on the ground or on air platforms, either attended or unattended, which are capable of detecting and identifying incursions under all conditions of weather and visibility. Rapid mobility can be attained through organising and employing quick reaction forces, supported by all-terrain ground vehicles or rotary wing aircraft. Precision attack can be attained through the employment of trained forces with weapons capable of destroying threats

[24] AAP 4130.001, *Ground Defence*, Section 1, Chapter 1, Annex A, pp 1A5-1A6.

well before they can affect friendly aircraft operations and at minimum risk to the defenders.

PASSIVE DEFENCE OF AIR BASES

The two necessary passive defence qualities sought in air base design, construction and operation are resilience and recovery to ensure that bases are difficult to attack and can be restored to use quickly following an attack. Building in resilience not only increases the cost of an attack necessary to incapacitate a base but also reduces the effects of attack. While resilience is a measure of an air base to sustain an attack, recovery is its ability to assess and repair damage expeditiously, thus allowing the early resumption of air operations. Both resilience and recovery come at increased costs to base construction and operation, with a common key to their success being the optimal utilisation of air base support personnel; for this reason, personnel will be considered separately.

Resilience

Resilience can be achieved through six major means: incorporating redundancy, dispersing assets, hardening facilities, and using camouflage, concealment and deception. Failure to incorporate all six can increase the effects and success of attacks against air bases.

Redundancy. Redundancy is the ability to switch to an alternate operating system when the primary system becomes inoperable. Such a feature comes at an additional cost that may be reduced but not eliminated through effective design. Essentially, redundancy requires duplication of one or more facilities, or using alternative but less capable resources. Loss of a main runway can be alleviated by use of secondary runways, auxiliary runways, and emergency runways. For example, some Iraqi Air Force air bases have ten or more levels of redundancy if use of the main runway is lost. Fuel storage can be divided into a number of sites so that the loss of one can be supplemented by another; otherwise air-to-air refuelling (AAR) or ground transfer of fuel from other aircraft can be used as alternate sources.[25] Other key assets and utilities require duplication or stockholding policies to ensure that a backup is available. Overall, redundancy is an anathema to efficiency measures but, without it, air power may cease to function in times of crisis.

Dispersal of Assets. Historical evidence indicates that dispersal of assets can be one of the most effective measures in limiting the effects of attack through reducing the concentration of assets. This reduction forces an attacker to use a larger attacking force or multiple passes, thereby increasing the risk of losses. Dispersal of aircraft, for example, employs parking areas such as hardstands, revetments or hardened aircraft bunkers some distance from the runway, some distance from each other, and aligned to reduce the effects of air or ground attack. The extra protection offered by dispersal comes at a cost in extra facilities such as the cost of longer taxiways, extra hardstands, the utilities required for connecting these sites, and an increase in CDAs for ground

[25] The feature of being able to transfer fuel to other aircraft on the ground is designed and built into the USAF's C-17 aircraft.

defence. An additional cost comes also in the loss of operating efficiency such as personnel having to travel further, longer taxiing times, and the longer transit times for replenishment vehicles. Dispersal may even involve outposting aircraft to other airfields but this adds an even greater cost to the loss of operating efficiency and responsiveness.

Hardening. Over the last 20 years, there has been an increase in the hardening of air bases through the use of stronger structures and counter-measures, usually at enormous cost. Physical strengthening to counter penetration weapons can be achieved through the use of stronger materials such as reinforced concrete, other hardened materials such as steel, covering with earth, burying the structure, or combinations of these. Paved surfaces can be strengthened through the use of reinforced concrete, increasing the thickness of the paving material or both. Aircraft parking areas can be strengthened through the use of earth filled revetments, building a shelter covered in earth, or building a hardened aircraft bunker incorporating reinforced concrete, hardened steel doors and earth covering. Other key facilities such as command, control and communication centres, personnel protection shelters, fuel tanks, and munitions sites can be hardened by strengthening the structure, covering with materials such as earth, or building the structure underground, or a combination of all of these. A crucial and essential form of non-physical hardening is the protection of information systems against information attacks. Other forms of non-physical hardening are the measures to prevent air in enclosed working areas being contaminated by the effects of nuclear, biological or chemical weapons.

Camouflage, Concealment and Deception. Camouflage, concealment and deception (CCD) offer some of the cheapest and most effective forms of resilience. Camouflage uses materials and techniques such as netting, etching, colouring, contrasting and toning to assist in the concealment of facilities, operations and personnel. Using measures usually best incorporated early in air base design, concealment prevents detection or observation of key facilities or operations in progress. Methods of concealment include burying structures, using structures or natural features such as vegetation for masking, or by using structural shapes, materials or procedures to reduce sensor signatures. Deception aims to divert enemy attention from high value targets. Methods of deception include constructing decoys such as pavements, buildings and aircraft, using innocuous buildings for performing critical functions, and producing deceptive signatures for sensors. Incorporating as much CCD as possible into the original design and construction of air bases reduces the time and costs of upgrading for contingencies. Although the argument may be made that investment in CCD is nugatory in an era of PGMs, any tactic that makes air base attack more difficult or expensive, without prohibitive costs, is worth incorporation.

Recovery

Recovery begins during the attack phase the instant damage occurs and continues during the post-attack phase until normal operations have been resumed. Recovery can be achieved through timely damage assessment, emergency response, the rapid repair of key assets and the restoration of essential services, and the replacement of losses to personnel and key assets.

Damage Assessment. The first task in the post-attack recovery phase is the assessment of damage and dangers, and the actions required for the restoration of base operations. Some of the requirements for this task are mobility for the safe observation of damage, an effective communications net, assessing and mapping the damage, and producing a recovery action plan. Assessment of damage to paved areas, for example, will decide the type of repairs necessary and the resources required while an assessment of unexploded ordnance will determine priorities for disposal and the paths for safe passage through affected areas. Part of the assessment process should also be the continued posting of warning signs to indicate danger areas and safe passages of transit. Use of an air observation platform, such as a rotary wing aircraft or a UAV, can greatly speed the process of observing and mapping damage.

Emergency Response. Emergency response is aimed at assessing and containing the effects of attack. Examples of tasks performed by the various air base emergency response teams are firefighting, the rescue of personnel, casualty treatment and evacuation, the restoration of key utilities, the disposal of unexploded ordnance, posting of warning signs, and the clearance of debris and obstructions from aircraft operating surfaces. Work performed by the teams will continue from the attack phase to the post-attack phase. As response groups may be overwhelmed, commanders will need to prioritise carefully in allocating personnel to tasks.

Rapid Battle Damage Repair. In most instances, the greatest challenge in post-attack recovery is the rapid repair of runways and taxiways to restore minimum operating surfaces. A pre-requisite to rapid repair may involve the clearance of unexploded ordnance such as defective, timed-delay or mine munitions. The latter two types are aimed at causing maximum disruption and damage to battle damage repair teams. Earth-moving vehicles with protective armour may need to be employed not only for repair tasks but also for preliminary movement of unexploded ordnance. Crater damage to paved surfaces is classified according to the depth of penetration, crater shape, and the undermining or the lifting of surfaces surrounding a crater. Repair teams will require specialised equipment such as excavators and compacters, as well as stockpiled materials for underlays and surfacing. Surface repairs over a compacted underlay may be effected by using matting, concrete slabs or a quick drying flood grout (about 30-45 minutes drying time). Crater repairs need to be exact, especially to those where the explosion causes a heave effect, raising the surface surrounding the crater edge. Aircraft moving at speed over any irregularities introduced into surfaces by inadequate repairs may reach their natural resonance frequency and so suffer structural damage.[26] For other critical facilities, the expediency of their repair for the restoration of essential services will depend on the level of redundancy, stockpiled materials and spares, and the number and competencies of repair personnel.

Preparation of Personnel

An air base resilient in all the features discussed is of little use if the performance of personnel is so seriously degraded by attack that they cannot participate effectively in base recovery. In 1985, the USAF conducted Exercise SALTY DEMO at Spangdahlem Air Force Base in Germany to test base survivability against a moderate

[26] Bahm, Capt Peter C., USAF and Polasek, Capt Kenneth W., USAF, 'Tactical Aircraft and Airfield Recovery', *Airpower Journal*, Summer 1991, p 50.

level attack. The exercise incorporated as much realism as possible, including actual holes blown in paved surfaces, fires, unexploded ordnance, and the removal or reduction of those essential assets, utilities and personnel assessed as affected by attack. Of the many lessons learnt and incorporated into the 316 exercise report recommendations, the most telling were those showing how much the effects of air base attack on personnel could seriously degrade operational effectiveness. As a result, the USAF introduced an ABO program to prepare air base personnel to 'defend themselves, ride out an attack, recover from it, and get back into action'.[27]

The lesson for all air forces is that the competencies and attitudes required for air base personnel to prepare for, sustain and recover from the effects of attack must be identified and incorporated into realistic and sustained training. In addition to personal readiness requirements such as health, dental and physical fitness, skills beyond those required for primary duties may include ground defence, firefighting, first aid, explosive ordnance disposal and assisting in the rapid repair of facilities. Such skills can be provided relatively easily, but must be reinforced regularly by realistic training in exercises that simulate the demands, stress and duration of sustained air base attack if the necessary physical and mental preparation is to be achieved. While such training is expensive, competing with other demands in the depths of peace, its incorporation into ABO requirements is vital.

ALTERNATIVES TO CURRENT SYSTEM

Air bases in an AO carry a cost premium in terms of infrastructure, defence and resupply. Every aircraft based in an AO strains supply chains through such needs as fuel, munitions, spares, maintenance equipment and personnel support, thereby increasing the 'deployment footprint'. Any alternatives, that may possibly reduce the costs of operating air bases in the AO without seriously compromising responsiveness, reach and versatility, require consideration. Some alternatives are aircraft carriers, use of V/STOL aircraft, basing aircraft outside an AO and the use of modified roadways as main operating surfaces. While each of the alternatives has its benefits, each also has its limitations.

Aircraft Carriers. Aircraft carriers are essentially mobile airfields for force projection, using an infrastructure similar to that found at most air bases to support air operations. Only the US employs carriers large enough to operate large numbers of high performance aircraft for most roles. France operates smaller carriers with smaller numbers of high performance fixed wing aircraft. Most other navies with aircraft carriers employ small numbers of V/STOL aircraft such as the US AV-8 series Harrier, the British Sea Harrier series and helicopters, all with some limitations in range, payload and performance. The cost of a US attack carrier is in the range at $4-5 billion each (without aircraft) while even the cost of the smaller carriers such as Spain's *Principe de Asturias*[28] class and Italy's *Giuseppe Garibaldi* class is

[27] Correll, John T., 'Fighting Under Attack', *Air Force Magazine*, October 1988, p 54.

[28] Thailand has recently acquired a new carrier, the *Chakkrinureubet*, of the *Principe de Asturias* class at a cost of US$257 million but built to merchant marine standards. This cost does not include its aircraft and details are not known as to what C3I systems, if any, are included in this cost, but the eventual cost is estimated at US$1.028 billion. Source: *Asia Military Review*, Volume 3 Issue 4, August/September 1995, p 78.

significant. But the initial cost of these cheaper carriers is only a fraction of the cost of protecting them from air, surface and sub-surface threats. Their protection diverts a significant component of their air capability, requires comprehensive command, control, communication and intelligence (C^3I) systems to coordinate their air group operations, and requires a protective screen of vessels.[29] Even with this protection, the precision and lethality of modern weapons limits the risk to which aircraft carriers can be exposed, as proven in the Falklands War. Further restrictions are imposed by their high operating costs including large crews, and their withdrawal for refit and maintenance requirements.

Bases Outside an AO. Some of the risks to air base aircraft, assets and personnel can be reduced by operating from bases outside the AO. Such basing in a safer environment also permits employment of civilian support personnel at lower costs and reduces the demands on supply chains to bases in the AO. Despite these benefits, there are significant overheads. Responsiveness is immediately reduced due to the longer transit times which correspondingly increase aircrew fatigue and life cycle costs. Unless aircraft have adequate ranges they will require forward refuelling or AAR to complete their missions, imposing the costs of additional capabilities. Use of bases outside an AO also may increase their potential as targets to enemy ground attack or sabotage.

V/STOL Aircraft. V/STOL aircraft use relatively small, rudimentary areas on land or at sea without the vast main operating surfaces and fixed infrastructure of a normal permanent operating base. On land, aircraft can operate closer to the forward line of troops from highly mobile bases, thereby increasing sortie rates, base survivability and the operability in weather normally unsuitable to conventional take-off and landing aircraft.[30] Smaller operating areas are easier to defend and aircraft can be dispersed more easily, using where available natural vegetation such as trees for camouflage and concealment. Some limitations compared to most conventional take-off and landing attack aircraft are imposed, however, by the range, speed and payload of current V/STOL attack aircraft, such as attack helicopters and Harrier-type aircraft. Even with their smaller payloads, Harrier-type aircraft at maximum take-off weight require some forward take-off run. Some relief could be provided by using AAR to give greater range, as well as trading fuel for ordnance at take-off. Future relief may be provided by the V/STOL version of the Joint Strike Fighter (JSF) being developed to replace current fighter and attack aircraft in the US and UK inventories. The USAF has indicated that it may possibly buy 50-100 such aircraft for 'emergency deployments to areas with poor airfield facilities'.[31] The survivability, lethality and reduced life cycle costs planned for the JSF, combined with lighter munitions resulting from miniaturised munitions programs, have the potential to provide an effective attack aircraft without a dependency on large, permanent air bases for operation in an AO. Australia has already indicated an interest in the JSF as a possible

[29] Preston, Antony, 'Air Power at Sea - Trends in Regional Naval Aviation', *Asian Military Review*, Volume 3/Issue 1, February/March 1995, pp 34-38.
[30] Prater, Maj Jeffrey C., USAF, 'VSTOL and Power Projection: A Leap in Faith', *Airpower Journal*, Summer 1991, p 64.
[31] Braybrook, Roy, 'Joint strike fighter - best or bust?', *Asia-Pacific Defence Reporter*, February-March 1997, p 15.

candidate in the F-111 and F/A-18 replacement program, but such considerations will need to consider range limitations.[32]

Use of Roadways. The use of roadways as alternate main operating surfaces or emergency airfields is included as an operating option by a number of the world's air forces but is practised on a regular basis only by the Royal Swedish Air Force. Sweden incorporates structural modifications into its highway system so that sections of roadway can be transformed quickly into runways capable of handling all tactical aircraft in its Air Force's inventory. These sections include taxiways to allow for aircraft dispersal in wooded areas; mobile ground support equipment allows quick and easy deployment of supporting personnel. Procedures practised in deployments to roadway surfaces include fast turnarounds by maintenance, replenishment and rearming crews not only to increase sortie rates and but also to reduce the exposure of aircraft to both air and ground attack.

EVALUATION OF RAAF AIR BASE OPERABILITY

During World War II, the RAAF developed considerable expertise in air base operability in its campaigns across the world. In the Pacific theatre, the RAAF consolidated at bases in Australia and New Guinea after the hard fought retreat through Malaya and Indonesia, where a number of personnel and aircraft were lost on the ground to airfield attacks. Gradually, more effective active and passive defences, including organic air base ground defence forces, were developed to combat these attacks. As the Allied effort in the Pacific switched to the offensive, improved mobility in air base support was developed to allow squadrons to move forward to new airfields. After the war's end, the RAAF consolidated its force into a small number of permanent bases, forgetting many of the hard won lessons of World War II, especially in passive defence. Those and other more recent lessons learnt from other air forces, however, have been or are being incorporated into the ring of defensive bases constructed across Australia's north, as well as in the concepts of operations being practised.

ADF Air Base Roles and Functions

Over the last 30 years, the RAAF has established a presence in northern Australia through the development of permanent operating bases, or main support bases, at Tindal (near Katherine) and Darwin, and semi-permanent operating bases, or bare bases, at Learmonth, Curtin (near Broome) and Scherger (near Weipa). Only RAAF Tindal has a permanent combat aircraft presence with a squadron of F/A-18 Hornets. RAAF Darwin has extensive permanent facilities and personnel to support transit aircraft and exercises, as well as a Control and Reporting Unit, but this presence will decrease as RAAF Tindal's capacity for aircraft increases. The concept of the bare bases is to activate them only for exercises or conflict. These bases have major main operating surfaces, fuel facilities but a limited infrastructure. For exercises, advance parties under the command of the Operational Support Group (OSG), based in Townsville, deploy to selected bases to activate them by establishing the additional

[32] Fulghum, David A., 'Australia to Join JSF Program Soon', *Aviation Week and Space Technology*, 25 August 1997, p 52.

infrastructure and facilities. The people and equipment for the supporting air base wing, the air base defence and the supported squadrons then move in by land and air.

Other air bases may be established for exercises and contingencies by using existing civil airfields as semi-permanent operating bases for Point-Of-Entry (POE) purposes to an AO, such as the airfield at Kununurra; RAAF bases also are used as POE airfields. Additional infrastructure and facilities required for ADF air operations are again supplied by OSG. Temporary operating bases also may be established at suitable sites as forward operating bases for use by light tactical transports operating from POE airfields in support of forward ground forces, Army Aviation elements, or naval air elements. The people, equipment and facilities to support the operational and defence elements will vary according to the temporary operating base role.

The vital role of air bases was identified in the RAAF's original air power doctrine issued in 1990 and further developed as a result of the Review of Air Base Support (RABS) project conducted in 1993.[33] Among the outcomes of the review was the development of a standard RAAF-wide base support organisation and accompanying processes so that personnel deployed from various permanent operating bases to an activated bare base could adapt quickly to the new working environment. Although the ideal system would be to deploy all the supporting people from the same base as the supported units to maintain group cohesion,[34] there are several obstacles for the RAAF as a small air force. Air Base Wings on most RAAF bases support a variety of units performing flying roles, non-flying roles or both. While all or part of some units at specific permanent operating bases may deploy to an AO for exercises or conflict, other units or the residual component of deployed units remain behind. The deployment of complete specialist support groups from the one base to maintain group cohesion is difficult, without leaving an inadequate number of the people to perform the residual support functions. Similarly, base support personnel deployed to a base in the AO may be supporting attached units not from their parent bases. Unless this obstacle to cohesion can be resolved organisationally, other measures must be adopted to compensate during deployments.

Air Base Facilities

The characteristics of RAAF air bases and their facilities vary significantly, depending on their age. Southern bases are more compact and smaller in area than the northern bases, reflecting the era of their construction and the perception that their distance from immediate threats ensured security. While Learmonth was the first of the bare bases constructed in the north, its design reflected the southern base style with its lack of dispersal and redundancy capabilities. RAAF Tindal was the first base constructed to incorporate many of the lessons learnt in past air wars, especially dispersal and redundancy capabilities. Subsequent lessons learnt, however, have been incorporated into Curtin and Scherger. Incorporating dispersal and redundancy capabilities has come not only at a financial cost but also at the cost of creating a large area to defend.

[33] *Report of the Review of Air Base Support*, Canberra 1993.
[34] Williams, Gary, *The Power of Many: The Human Factor in Air Power*, RAAF Air Power Studies Centre, Canberra 1997, pp 29-53. In the report of his Chief of Air Force Fellowship study, Williams identifies the importance of cohesion to unit combat effectiveness, citing as an example the US problems arising in the Vietnam War from individual rather than unit replacement.

Operating surfaces at most RAAF bases are generally runways and taxiways made of asphalt over compacted underlay with hardstands made of concrete or reinforced concrete. Fuel facilities at southern bases are generally above ground while those at the northern bases are below or almost below ground. As part of bare base activation, deployable navigational aids, control towers and communications equipment are installed. Buildings at the bare bases are limited to underground operations centres, aircraft shelters and some transportable cabins; the remaining accommodation for personnel and work areas is met by tents provided by OSG.

Likely Threats

Australia resides within a region that is comparatively peaceful but dynamic in its growth, strategically and economically. While there is presently no threat to Australia's security, defence guidance acknowledges the potential for regional growth to fuel instability and to cause a deterioration in security. With this absence of identified threats, Australia's defence planning to date has been capability-based, using the premise that the development and maintenance of capabilities to resist aggression contributes to making war less likely. Underpinning these capabilities is depth-in-defence, a strategy that exploits Australia's geographical and technological advantages to detect and engage any hostile forces using a 'layered series of capabilities'.[35]

While any substantial assault against Australia is highly unlikely, its likelihood cannot be entirely discounted. Similarly, the possibility of deploying ADF air assets overseas in support of a scenario involving coalition air operations cannot be discounted. In either situation, the RAAF's doctrine on the employment of air bases in support of air power must be rigorous enough to address the major issues and to adapt to emerging scenarios. In any defence of Australia scenario, the ADF's air power and supporting surveillance systems will play an instrumental role in detecting and engaging hostile forces before any lodgement on Australian territory. Any hostile action against Australia, therefore, may be expected first to target these air power and supporting surveillance systems. Correspondingly, the ADF could be expected to target as a matter of priority similar centres of gravity for any enemy threatening Australia's interests. With the isolated location of most of the RAAF's northern bases, vulnerabilities such as the main supply routes, utilities and communications may be targeted to isolate a base or to reduce its capabilities. Examples of vulnerabilities are water supplies, Learmonth's proximity to the sea, the single land main supply routes to Scherger, the sea routes for transporting fuel, and the monsoon effects on some land main supply routes.

With the likely threat scenarios against Australia being difficult to predict, several forms of attack are possible. An enemy, for example, with a weak air force may attempt ground attacks against air assets and the surveillance systems. Similarly, an enemy with a strong air force may attempt air attacks simultaneously against the surveillance and command and control systems, and the air bases. To minimise casualties and the loss of valuable platforms, stand-off weapons may be used at the start, possibly coordinated with ground attacks by special forces. The possibilities

[35] *Defending Australia Defence White Paper 1994*, Australian Government Publishing Service, Canberra, pp 7-29.

widen further when considering deployments of ADF air elements to foreign bases as part of coalition or UN operations. While prediction is obviously difficult, it offers no excuse when weighed against the repercussions of an air base devastated by an attack for which it was not prepared. Air base operability in the ADF, therefore, must be structured for all contingencies in Australia and overseas.

Active Defence Against Air Attack

Many projects are currently proceeding to rectify problems in the ADF's organisation, equipment and doctrine impacting on air bases. The largest organisational improvement is the implementation of the ADF revised command arrangements project, which started in 1996 with the establishment of new headquarters at the strategic and operational levels. Most significant is the establishment of Headquarters Australia Theatre for theatre operations, and Headquarters Northern Command and a Deployable Joint Force Headquarters (Land) for operations at the JFAO level. For the air defence of the Australian theatre, the ADF Air Defence System is being developed, with the Air Commander Australia being appointed as the Australian Theatre Air Defence Commander. Within the RAAF, a Surveillance Control Group is being established to optimise the battlespace management provided by new capabilities such as AEW&C and the Jindalee Over the Horizon Radar Network (JORN). Air bases play a vital role in these new systems and organisations.

Central to the defence against air attack are the surveillance systems, and the command and control systems that they serve. Without the information and directions provided by these systems, the aircraft launched from the air bases cannot engage an enemy effectively and efficiently. The protection of surveillance, and command and control sites, as well as their links through the civil telecommunications infrastructure, from both air and ground attack is essential. Sites located on air bases fall within the normal air base protection measures; sites outside the air bases will also require protective measures. This latter task is difficult for Australia with the sensors employed by the JORN and the deployable radar heads employed by the CRUs often being in remote locations, data-linked to operational centres. While the centres may be in hardened locations, the vulnerabilities of the sensors makes them high priority targets. These sensors will need to be protected against air attack by anti-radiation missiles, ASMs and conventional weapons, and ground attack by SF units. While radiation procedures may help counter anti-radiation missiles, and regular dispersal of the deployable heads may increase the difficulty of predictive targeting, the fixed nature of the JORN sensors requires the inclusion of damage repair and redundancy procedures in future plans to counter possible successful attack.

Current ground defences against air attack are totally inadequate for other than the most limited threat. While the Australian Army has Rapier and RBS-70 SAMs, these are primarily for the defence of their fielded units. Even if these were allocated for the defence of air bases and associated assets such as surveillance sensors, their number would still be inadequate against determined air attacks. Combined with this inadequacy is the absence of any AAA, a capability considered until recently as markedly inferior to SAMs. Any past criticisms of AAA have been overcome by modern systems such as the Oerlikon-Contraves GDF-005 which provides fire control and cuing, automatic and all weather operation, and a higher single shot kill

probability through improved ammunition.[36] Such weapons may influence the direction of attacking aircraft, force them higher into missile engagement zones, or distract aircrew in their target engagement and weapons aiming. Mounting these weapons on self-propelled platforms, such as the German Gepard Self Propelled Anti-Aircraft Gun (SPAAG) system or the US Lockheed Martin M163 SPAAG system, increases the difficulty of enemy attack planning and suppression of air defence targeting, thus aiding survivability.[37] Although the current threat environment makes the acquisition of such systems a low priority in comparison to the need to replace and upgrade other ADF capabilities, contingency planning must address these AA inadequacies at air bases and sensor sites.

Active Defence Against Ground Attack

Current defence plans assign major responsibility for the vital asset protection of the RAAF's northern air bases against ground attack to units of the Australian Army. These units normally assume responsibility for the security of the PSA. For the security of air base CAAs, three Airfield Defence Squadrons (AFDS) are currently established in the RAAF. Security of the CDAs is the responsibility of the Base Combatant Personnel (BCP) organisation which is comprised of all base personnel except operational aircrew and non-combatants. To qualify BCP for their tasks, they are given training in weapons handling and ground defence skills, while some selected personnel also are given training in explosive ordnance disposal. During exercises and conflict, BCP are employed for eight hours in their primary duty and four hours on BCP duties over the next 16 hours.[38] Using the experience of SALTY DEMO, the ability of personnel performing critical tasks such as aircraft maintenance and munitions handling, to function effectively after sleep disturbance or deprivation, resulting from BCP duties, must be questioned.

The approach adopted by the RAAF to air base defence is sound, with the BCP concept being foreseen in Churchill's observation of the RAF as far back as 1941 when he noted that 'every airfield should be a stronghold of fighting airgroundmen, and not the abode of uniformed civilians in the prime of life protected by a detachment of soldiers'.[39] Particularly, the BCP concept mobilises almost all of the base population towards ensuring the security of the air base. Doctrine for the integration of ground defences against ground attack on air bases also has made significant progress over the past 15 years and is still being refined. Many difficulties still exist, however, and need to be resolved. These concern assignment of assets, scale of responsibilities and equipment.

While Army units are assigned to protect the air bases, no formal agreement exists confirming this arrangement. In the US, a Memorandum of Agreement in 1984 allocated the defence of USAF bases outside continental US to the US Army Military

[36] Nash, Trevor, 'Air Defence - A Misunderstood Necessity', *Asian Military Review*, Volume 5/Issue 3, June/July 1997, pp 40-41.
[37] Cullen, Tony and Foss, Christopher F. (Eds), *Jane's Land-Based Air Defences* 1997-98, Jane's Information Group, London 1997, pp 57-89.
[38] DI(AF) OPS 5-3, pp 1-3.
[39] Quoted by Bell, Brig Gen Raymond E., USAR (Retired), 'To Protect an Air Base', *Airpower Journal*, Fall 1989, p 12 and drawn from Winston Churchill, *The Second World War*, Volume 3, 'The Grand Alliance', Houghton Mifflin Co, Boston, 1950, pp 776-777.

Police Corps.[40] Competition for the ADF's limited resources in any conflict will be high, and the potential exists for some or all of the Army's assets allocated for air base defence to be diverted to other tasks. Diversions could result, for example, from political pressure exerted after enemy attacks on, or harassment of, isolated settlements or towns. If sufficient Army assets cannot be guaranteed, the AFDS task increases significantly in defending the PSA as well as the CAA, both of which are extremely large at most northern bases. Compounding this scale of responsibility is the protection needed for isolated sensor sites and against possible attacks to isolate bases. Addressing this potential scale of responsibility depends partly on the equipment employed by the AFDSs.

At present, the AFDSs have only limited mobility to perform surveillance, reconnaissance and rapid response tasks. Current vehicles are adapted rather than purpose built, soft skinned and unsuitable for all-terrain coverage. Helicopters would be ideal for the task but their allocation may be unlikely in the order of priorities. Purpose built, all-terrain vehicles incorporating armour and mountings for suitable defensive weapons should be considered as a future capability. Even with better vehicles, the AFDS force size may still be inadequate to provide regular surveillance of the large areas against large threats. Tactical UAVs are one option for providing real-time electro-optical, infra-red and synthetic aperture radar imagery as part of regular, all weather surveillance. With the probability of most ground attacks occurring at night, the AFDS's night surveillance and fighting capability is being enhanced with the acquisition of night vision equipment under Project Ninnox.

Passive Defence Against Attack - Resilience

Many of the past lessons in passive defence measures have been or are being incorporated into the design of new bases in terms of redundancy, dispersal, hardening, camouflage, concealment and deception, and preparation of personnel. Redundancy in the main operating surfaces has been achieved by designing and constructing taxiways to serve as emergency runways. The RAAF bases at Tindal, Curtin and Scherger can employ up to four runways, using such designs as a 'coathanger' shape, with the main runway forming the base and the taxiways forming the angled sides. Redundancy in fuel supplies is being progressively addressed by increasing the number of separate fuel storage facilities. Although redundancy in power supply is addressed by emergency electricity generators, similar backups are needed in water supply and telecommunications.

Dispersal is well addressed at some bases, with hardstands leading off non-emergency-runway taxiways being aligned such that no more than two dispersal hardstands are in line to minimise the potential damage of air attack passes. Improvements to the aircraft dispersal areas for the other northern bases are being addressed in current facilities planning. Key facilities such as fuel storage, and explosive storage, preparation and loading areas are also dispersed. The Gulf War showed that even with the best dispersal of aircraft protected by hardened aircraft bunkers, they remained fixed, easily located targets against determined, precision attack. Nevertheless, hardened aircraft bunkers should not be dismissed immediately

[40] *ibid*., pp 10-11.

as obsolete as they still place extraordinary demands on an attacker's capabilities.[41] Dispersal of aircraft to other sites such as other Service air bases, civilian airfields, or emergency main operating surfaces, such as roadways, without a significant degradation of responsiveness, therefore, should be another important consideration in contingency planning. Such planning would need to identify suitable sites, requirements, modifications and the need for pre-positioned stocks, such as fuel, munitions and support equipment. Opportunity costs also would be an important consideration with the cost of possible lengthening and strengthening the runways at selected civil airfields, for example, needing to be weighed against the cost of constructing improvements such as hardened aircraft bunkers at permanent operating bases. Likewise, the benefits of dispersal to other airfields would need to be weighed against any limitations such as reduced responsiveness and the additional costs of positioning operational support at those airfields.

Dispersal areas at some of the RAAF northern bases employ revetments of concrete and earth for the protection of aircraft and personnel against blast, ground fire and sympathetic detonation. Aircraft entry and exit to these dispersals are duplicated for redundancy purposes. An igloo type roofing covers many dispersals only as a weather protection; these shelters are strong enough to support only a thin coating of earth for additional protection. A cheap option for further protection could be the draping of armoured metal netting over the structure to absorb blast fragments but this is significantly inferior to a hardened aircraft bunker. While the construction of hardened aircraft bunkers would be a preferred solution despite their ease of targeting, their high cost is currently prohibitive. A proposal has been made that developing and producing a prototype hardened aircraft bunker could reduce the lead time for the construction of others in a contingency by up to 80 per cent.[42] Careful analysis needs to be done in weighing up the substantial investment in hardened aircraft bunkers and their vulnerability as fixed targets, versus the investment in additional but unsheltered dispersal sites at other airfields as described earlier.

Hardening of other structures has been achieved by such measures as the location of reinforced concrete command centres underground, the burying of fuel tanks, the bunkered construction of munitions stores and preparation areas, and the strengthening of BCP accommodation. For hardening against the possible use of biological and chemical warfare weapons, current and future buildings should incorporate a capability to install suitable decontamination and filtering equipment.[43] While the RAAF is currently establishing a capability for military information operations, considerable work has still to be done in hardening its information systems against attack.

Camouflage and concealment are being progressively achieved using such measures as low visibility surface coverings to tone down structures, low profile, sunken or buried structures, and a high use of natural vegetation in areas other than main

[41] Waters, Gary, *Gulf Lesson One - The Value of Air Power: Doctrinal Lessons for Australia*, RAAF Air Power Studies Centre, Canberra, 1992, p 151.
[42] Hammond, WGCDR O.J., 'Iraq's Preparation for the Gulf War - Lessons for RAAF Operational Facilities Planning', p 75 from Waters, Gary (Ed), *Line Honours: Logistics Lessons of the Gulf War*, RAAF Air Power Studies Centre, Canberra, 1992, p 78.
[43] *ibid*., p 77.

operating surfaces and ground defence free-fire zones. Earth walls and overhead covers topped with local grasses are used for camouflage, protection against direct and indirect fire, and the reduction of noise and infra-red signatures. Despite its proven success as a highly effective passive defence measure, deception is not used at current bases, although the DSTO is researching the issue. Future contingency planning should include the construction of decoy pavements, buildings and aircraft, disguising of buildings to resemble less critical functions, and the modification of radar and infra-red signatures as part of deception, as well as the use of smoke generation as part of concealment.[44]

Passive Defence Against Attack - Recovery

Four major emergency response teams are involved in recovery operations both during and post attack: firefighting and rescue, medical, explosive ordnance disposal, and battle damage assessment and repair. Although the numbers of specialists employed at air bases might be adequate to cope with the effects of minor attacks, they are unlikely to be adequate to cope with the effects of a major attack and thus will require augmentation. The present augmentation system has people allocated to the BCP organisation, with most emphasis being on ground defence duties. Some personnel do receive specialist training for explosive ordnance disposal and some augment firefighting personnel in countering bushfires as part of defence aid to the civil community.

The training and preparation of emergency response teams requires further examination. While considerable effort is expended in providing realistic and appropriate training for aircrew through the provision of simulators, ranges, exercises and exchange duties with other air forces, there is relatively less emphasis on the necessary training and preparation for the less glamorous tasks that comprise ABO. Increased opportunities for ADF firefighting and rescue crews, and ADF medical teams to serve on exchange duties with their civil emergency service counterparts would give exposure to scenarios and casualties approaching those likely to be encountered in an air base attack. Medical teams, as well as leaders, especially need to gain training and experience in the causes, recognition, treatment and prevention of battle fatigue to reduce the number and effects of psychiatric casualties.[45] While current explosive ordnance disposal tasks and training emphasise civil bomb threats scenarios, the unexploded ordnance problems likely to be encountered in an air base attack, especially the countering of area denial weapons, need also to be emphasised.

Apart from damage to aircraft and fuel supplies, damage to the main operating surfaces is the attack effect most likely to influence the generation of missions. Battle damage repair of these surfaces, especially rapid runway repair, therefore, will be amongst the highest priorities of the OSG Operational Facilities Flights (OFF). Although USAF civil engineer teams, for example, practise rapid runway repair of

[44] *ibid*., pp 75-76. In examples quoted, the construction of a base switchboard inside a library by the Iraqis during the Gulf War allowed functional communication for the conflict while the disguising of heavily reinforced concrete structures as steel-clad structure caused the Coalition to attack with inappropriate weapons.

[45] Bingham, LTCOL Price T., 'Fighting from the Air Base', *Airpower Journal*, Summer 1987, p 40. (This article emphasises that in the 1973 Yom Kippur War, the Israeli military experienced 30 psychiatric casualties for every 100 who had physical wounds.)

simulated runway damage under battle conditions including chemical attack,[46] such repairs are not presently practised by the OFFs as part of current training and exercises, although some of the skills are practised in their exercises with Australian Army Combat Engineer units. Contingency plans for developing a rapid runway repair capability should include the selection of techniques, the acquisition of equipment, the availability of repair materials, and the training of OFF and augmentation personnel. Equipment considerations should include personnel protective measures such as armoured bulldozers for working in proximity to airfield attack weapons, the pre-positioning of repair materials and equipment, and the protection of personnel, material and equipment against attack. Testing of a rapid runway repair capability would need to include the effects of weather, attack profiles and the countering of unexploded ordnance.

Part of the OFF responsibility is to provide airfield battle damage assessment and repair. As a means of better utilising deception as a passive defence, damage assessment should include the identification of deceptive measures likely to confuse any enemy bomb damage assessment. Such measures may include the painting or construction of damage to main operating surfaces, buildings and dispersal areas.

Active and Passive Defence - Personnel

Examination has shown that the active and passive defence of air bases depends on the one major resource which the ADF most lacks - numbers of people. Bases are manned primarily with the number of people required to generate air missions and to provide the minimum capability for active and passive defences. The variations in the types and intensity of air base attacks from the air and the ground can cause corresponding variations in the types of responses required, the response priorities, the recovery actions, and the physical, mental and skill demands placed on support personnel. These demands require air power to have the same versatility on the ground for maintaining ABO as it has in the air. This versatility on the ground can be achieved only by multi-skilling the right number of people and developing the right attitudes. The latter especially need to be inculcated as the intense combat, sleep deprivation, indirect fire and surprise arising from possible air base attacks can lead to psychiatric casualties.[47]

Threats likely to be applied against an air base in conflict generate different demands on support personnel from those generated in peace, particularly in the type, volume and intensity of tasks performed. While the types of tasks in conflict reasonably can be predicted, the volume and intensity cannot without accurate intelligence of the threats. Numbers of personnel, therefore, need to be adequate to cope with unexpected, as well as expected demands both inside and outside an AO. Unexpected demands may include, for example, activation of more bare bases, the use of more civilian airfields, increased ground defence requirements or increased base recovery workloads. Deploying additional personnel from bases outside an AO may meet these demands but only at the expense of tasks performed at those bases. But less uniformed personnel are now available as a result of initiatives such as the Members Required in

[46] Bahm, Capt Peter C., USAF and Polasek, Capt Kenneth W., USAF, 'Tactical Aircraft and Airfield Recovery', *Air Power Journal*, Summer 1991, pp 47-51.
[47] Bingham, 'Fighting from the Air Base', p 40.

Uniform (MRU) program, efficiency reviews and structural reforms such as the Commercial Support Program. While such programs produce the necessary savings to fund other defence requirements, the smaller workforce numbers reduce the flexibility available for augmentation tasks. Many issues remain to be addressed as part of the MRU program including the inclusion of all ABO recovery skills with ground defence skills, the inclusion of these skills in the training of personnel recruited and qualified after the start of conflict, and the filling of vacancies at bases outside the AO created by unexpected demands at bases inside the AO.

Historically, air forces around the world have identified aircrew and those charged with the direct defence of the air base as the warrior group while those employed on combat support duties have been identified as the non-warriors. The latter RAAF group in World War II, for example, attracted the sometimes derisory term 'base wallah' while modern parlance sometimes uses the term 'blunties'. Naval units at sea have no such attitudinal problems with all support personnel having skills that contribute to a ship's operability in battle. Similarly, all army support personnel are expected to have core fighting skills for emergency situations in battle, such as enemy breakthroughs and the emergency replacement of casualties. Australia's air bases or bases employed overseas may be just as vulnerable to attack as any naval ship or army unit. Yet the loss of aircraft on the ground or air base operability, even for a short time, may have a detrimental and disproportionate effect on Australia's air power and overall defence capabilities.

Harnessing the potential of all air base personnel by providing multi-skilling focussed on ABO optimises resources to ensure that any attempts to impair mission generation are minimised. Such harnessing ensures that everyone on an air base is identified as a warrior and the 'one team' goal is a reality rather than a hollow exhortation in a planning document. Warrior recognition for all air base personnel by the RAAF leadership is a crucial step in changing the culture to shape the right attitudes. Developing the attitudes comes from defining the tasks, followed by the right training and experiences for the right people at the right times. All of this comes at a cost that must compete with the more glamorous weapons systems and munitions. But the latter are of little use if they are confined to, or destroyed on, the ground because insufficient resources were devoted to the key element of ABO - the people.

Attacking Enemy Air Bases

Just as the ADF must assume that any future conflict could include attacks against its air bases, so the ADF must plan also to attack any enemy air bases likely to threaten Australia's interests. All the concepts, skills and expertise required to analyse and protect vulnerabilities of the ADF's bases are similar to those required to identify and target enemy air base vulnerabilities. For a force as small as the ADF, the organisation that contributes to air base protection through vulnerability analysis should also contribute to the targeting process for enemy bases through a similar vulnerability analysis, using the best means of reconnaissance and attack, including SF elements.

Many different groups presently contribute towards ABO requirements but no coherent organisation is established to optimise the coordination. A USAF analysis of some of the miscalculations made in planning and executing Coalition air attacks during the Gulf attributed, as one of the causes, the lack of a dedicated organisation

responsible for studying foreign air base operations and their weaknesses.[48] History has proven that well planned, well executed air base attacks can bring triumph while the opposite can bring disaster. The ADF's assets for air base attack are too small and too valuable to risk squandering. Establishing an organisation, not necessarily collocated, that analyses and addresses air base vulnerabilities both for protection and targeting is essential for optimising air power application.

CONCLUSION

Ever since the attack by Jackson and Gornan on the German airfield at Lessines in 1914, air base attack has become a major instrument for targeting an enemy's air power. Even nations or states with little or no air forces can wreak havoc through ground attack against the air bases of an unprepared or complacent adversary. Air power's inherent strengths and its disproportionate effects in conflict make it an important target for winning any conflict. History consistently has proved Douhet's assertion correct that it is easier to destroy an enemy's aircraft on the ground than in the air. The increased dependency of modern aircraft on the extensive facilities of modern air bases, coupled with their immobility and vulnerabilities, make them high value targets and the major centres of gravity for all air forces. Air base operability provides air forces with the ability to withstand attacks and recover quickly to continue mission generation.

Analysing air base characteristics, design and construction is the first step in the ADF determining how best to protect its bases and to attack those of any enemy. Next, threats need to be identified in terms of their origin, possible effects and countering. Most threats usually start with the collection of information using surface, air or space based surveillance. Historically, air attack has been the most effective form of air bases attack and a variety of lethal and non-lethal weapons now exist, ranging from free fall bombs and PGMs to stand-off weapons. Stand-off weapons, while costly, reduce the threat from air base defences to the attacking force and are becoming more potent. Ground attack also has been successful, with the attacks by stand-off weapons being the most exploited form. A more modern form of attack that must now be considered is information attack, using military information operations. Active and passive defence measures in their various forms provide the means to withstand and counter the various threats and forms of attack.

The ADF employs a range of active and passive defence measures for possible attacks against its northern air bases, as well as employing significant capabilities for attacking air bases. Defensive air measures are considerable with air platforms, weapons, surveillance, and command and control capabilities all being currently improved. Ground based air defenses are totally inadequate and require significant expansion as part of contingency planning in both SAMs and AAA, including mobility to enhance survivability. Ground defences in the RAAF have improved organisationally and doctrinally, with the current low numbers of AFDS personnel being augmented by the BCP. While the remotest possibility exists for the diversion of Army resources from air base protection, contingency planning must address how

[48] Centner, 'Ignorance Is Bliss: The Big Lesson from Desert Storm Air Base Attacks', p 32.

the AFDSs might cope with the additional, as well as current, responsibilities in terms of resources, organisation and doctrine.

Significant improvements have been made to passive defences for resilience and recovery but more can be done. Redundancy in the main operating surfaces and fuel storage is incorporated into the newer bases and plans are place to address the deficiencies at older bases, except for the provision of water and telecommunication. Dispersal of aircraft on bases is improving but the doctrine for employing civil airfields, suitably modified road surfaces or bases outside the AO as a dispersal measure against attack, needs to be examined. The hardening of facilities has improved but a prototype hardened aircraft bunker needs to be developed to reduce building lead times for a contingency, provided analysis justifies the opportunity costs. While camouflage and concealment have improved, deception needs to be adopted and exploited. Recovery against attack is essential and needs to be part of the air base culture. Current recovery capabilities are limited and capabilities need to be expanded to encompass disposal of attack munitions and the rapid repair of damaged operating surfaces.

Air base operability must be recognised as an overall capability requiring a range of specialists and a dedicated organisation that addresses protective and attack measures. Importantly, all who contribute to air base operability through protection, defence and recovery operations must be recognised as warriors. As warriors, they must be multi-skilled, given realistic training and opportunities for experience, and imbued with an attitude of purpose that recognises their contribution to air operations. Aircrew have often said ‘There’s nothing more useless than runway behind you, altitude above you or air in the fuel tanks.’ Perhaps this could be modified to ‘There’s nothing more useless than a runway you can’t use, an aircraft you can’t fly or fuel that can’t be used.’ Air base operability is all about ensuring that these never occur.