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Evolution of Air Bases – Darwin Revisited

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'We shape our airbases: thereafter they shape us'[1].

The modern airbase is a product of evolution. Contemporary environmental factors, not all self-evident in retrospect, have shaped the current design. The emergent threat of longer-range and hypersonic weapons pose an existential risk to current airbase design and rightfully demands review. Airbases have been at risk or experienced air attacks before now, but only for relatively short periods in the century-long history of airbases. While the risk of attack has affected airbase design, it has not been the primary driver. Airbase design has been driven primarily by the fundamental requirements of runways, modified by contemporary technology and societal drivers. Future design will need to be sympathetic to current and emergent design demands beyond the single risk of air attack from advanced weapons.

Introduction

The aeroplane preceded the aerodrome. The Wright Brothers used a beach in North Carolina (USA) with predictable and steady winds for the first take-offs and landings. Prior to the First World War, there were no aerodromes as we would recognise now. The first dedicated landing grounds in the English-speaking world were associated with military training areas, such as Aldershot and on the Salisbury Plains (UK) and College Park in Maryland (USA). The Royal Flying Corps had a small number of landing strips alongside the Royal Aircraft Factory. The essential criteria for building an aerodrome were firm ground and a level (horizontal) and obstacle-clear field capable of supporting take-off and landing.

For all Commonwealth forces, including the Australian Flying Corps (AFC), the First World War was expeditionary; squadrons flew from temporary bases adjacent to suitable fields close to the front lines. Flying squadrons were 'in the field', literally. The Commonwealth forces had a number of aircraft parks (maintenance airbases), the largest at St Omer (**Figure 1**) and Heliopolis in Egypt. Although airfields were subject to air attack, ordnance size and accuracy limited damage. It was only sustained artillery or attack by ground forces that could cause the demise of a flying squadron's airfield.

Figure 1. Royal Aircraft Factory S.E.5a aircraft of No. 85 Squadron at St Omer Aerodrome, 21 June 1918. (Source: (Imperial War Museum, n.d-b)

[1] The quotation is from an unpublished work by WGCDR Rohan Gaskill, 'The Basis of Air Base Design'; the wording of the quotation was adapted from Winston Churchill's, 'We shape our buildings: thereafter they shape us'.

AIR AND SPACE POWER CENTRE

Before proceeding to further discussions of what an airbase is, it is useful to determine definitions. Oxford Languages defines an airbase as a military aerodrome. Airbases are a subset of aerodromes, which are defined by the International Civil Aviation Organisation (ICAO) as 'a defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and movement of aircraft' (ICAO, 2018). Aerodromes are now colloquially known as airports. Websters note that the first known use of the term airbase was in 1913, but the ICAO definition dates to 1951, some 38 years later.

This essay explores the evolution of the airbase over the century from 1920 to the present, identifying the core drivers of airbase design, including the technical, functional and even social drivers that emerged and, in some cases, disappeared over the century. In the current discussion around agile basing, 'stripping the airbase' – by removing many of the installations and populations from the workforce – is driven by the threat of modern air weapons. The cautionary note to consider is that the risk of air attack was, and is, only one of the threats to airbases in the generation of air power. For much of the twentieth century, the greatest threat to airbase security was from ground attack, in the form of incursion and short-range fire, or simply the environmental, technology or societal constraints placed upon airbase logistics and workforce at the time.

First Generation Airbase Design

Permanent airbases were a post–First World War development. Aviation was expanding, and with the return of peace, Commonwealth military forces returned to garrison disposition; both driving the building of permanent infrastructure. Logistic support was a major driver of early airbase location and design. Apart from the essential airfield terrain characteristics, access to supplies and workforce were limited by the transport technology of the time. Airbases needed to be proximal to railway lines and not too distant from population centres. Even in the First World War, this limitation was significant; the campaigns by No. 1 Squadron, AFC, based in Palestine, were defined (indeed constrained) by the rail lines back through the Sinai to Cairo and the aircraft park established at Heliopolis (**Figure 2**).

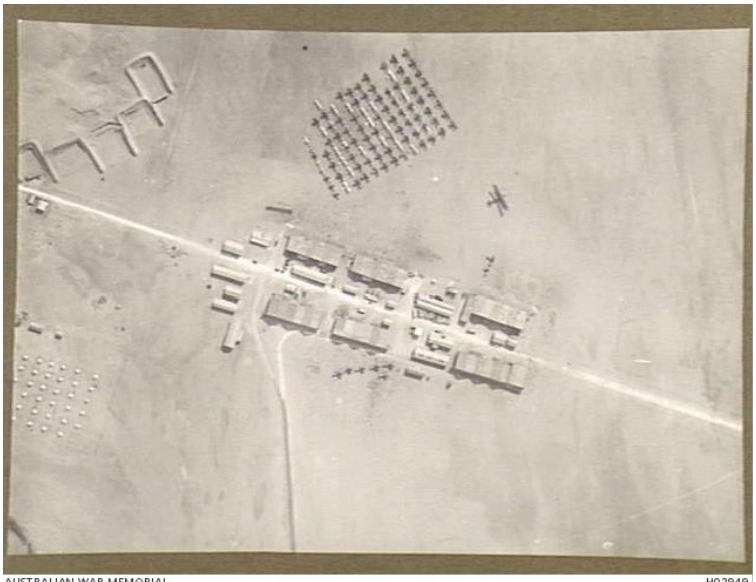

Figure 2. Heliopolis aircraft line up for inspection by General Allenby 1918. (Source: Australian War Memorial)

That lack of transport technology drove workforces to be co-located with the airbase. In the 1920s and 1930s, messes, accommodation and 'married quarters' for the air force workforce and families were constructed in addition to fixed-maintenance hangars. These structures were also constructed in relative proximity to the hangars and workshops due to the same lack of ground transport. Commuter workforces depended on railways, given the relative fragility and cost of motor vehicles at the time. As a result, airbases were generally close to major population centres with access to industry and ports.

Airbase design during this period was not primarily driven by runways and taxiways (the latter did not even exist) but rather by maintenance, logistics and personnel support. In deployed airbases, force protection was the greatest risk, particularly in the Middle East and North-West Frontier of India for the Royal Air Force (RAF) operations, where insurgents posed a real threat to personnel and their families. As late as the early stages of the Second World War, the flying surfaces of airbases were a cleared, roughly circular field with a centre point marked by whitewash; a perimeter path and take-off and landing areas were constantly moved, marked by a white 'L' depending on the prevailing wind direction of the hour (RAF, 1937).

During the interwar years, a paucity of airbases and airports limited aircraft design, and most long-haul aviation was via flying boats associated with coastal ports. The cost of sealing aerodromes was deemed prohibitive, particularly as the Great Depression set in. As long-haul, intercontinental flight developed, aerodromes tended to be 'a defined area of water' in the form of flying boat aerodromes (ICAO, 2018)[2]. Some, such as New York's La Guardia Airport, supported larger, long-range flying boats and smaller regional passenger and transport aircraft. The Royal Australian Air Force (RAAF) base at Point Cook was for land and seaplane operations at the time.

The changes in aircraft form factors, including designs that required access to landing fields, drove the 'traditional' red brick airbase design such as RAAF Richmond, Pearce, Point Cook and Laverton. Bases became largely self-sufficient

[2] **Aerodrome** [ICAO, Annex 14] A defined area on land or water, intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

towns with messes, schools, shops, recreation areas and family housing. This model was mirrored overseas for a different reason: protecting personnel and their families from attack by criminal or insurgent forces. A prime example of this was RAF Station Habbaniyah in Iraq, which was subject to ongoing attack throughout the pre-war and early Second World War periods. This threat evolved post-war in Britain with attacks by the Irish Republican Army on British home and Northern German military bases and had echoes in the design of the early history of our own RAAF Butterworth in Malaysia. Ground-based force protection, therefore, has been the greater driver of airbase support element design than air attack.

Figure 3. Wellesley Mark I K7740 of the Torpedo Development Unit at Gosport, Hampshire, following conversion for tests as a torpedo bomber. (Source: Imperial War Museum, n.d.)

The Second World War

The extensive paved areas of modern aerodromes originated because of the rapid increase in the operating weight and size of bombers and transport aircraft in the Second World War. A Vickers Wellesley had a maximum weight of 12,000 lbs (**Figure 3**). A fully laden Lancaster weighed over 60,000 lbs. A combat-overloaded B-29 of the United States Air Force (USAF) weighed over 135,000 lbs, comparable to a loaded C-130 Hercules. The building of bomber bases in Britain was in anticipation of the strategic bombing campaign of the RAF and USAF and the next generation of bomber aircraft. A design specification led to the 'A' design of three paved runways aligned to the prevailing wind and connected via a perimeter track, which became the standard airbase design of the mid to late war.

The strategic bombing of Japan resulted in the development of parallel taxiways and multiple runway airbases such as Tinian, which became the template for future airbase design. It was also the legacy of the mass building of such runways and aprons that facilitated land-based, larger, civil transport and passenger aircraft. The addition of parallel taxiways and high-speed ramps provided a degree of redundancy and efficiency to support wartime operations. With the ensuing peace after the Second World War, commercial cost imperatives and traffic volume drove the design of airbases, while safety demanded parallel taxiways and high-speed off-ramps (exit taxiways). In 1977, the safety risk of multiple runways was highlighted by the world's worst aircraft disaster, which occurred in the Canary Islands when a Boeing 747 landed on another while it was taxying in fog on the main runway (Tedeschi, 2019).

'Short Memories'

Up until the Second World War, there had not been any existential threat to airbases despite the forecasts by early air power theorists. However, the Battle of Britain saw a Luftwaffe campaign against the RAF. Within days, the RAF airbases suffered significant damage (Hooton, 2010). The response was immediate, in the form of camouflage and dispersal and, in the longer term, the hardening of structures and redundancy. The attacks on Pearl Harbor and Hickam Field should not have come as a surprise. More disturbingly, the lesson had not been learnt in Australia and the attacks on Darwin just a couple of months after the Pearl Harbor bombing demonstrated little preparation or appreciation of the risk of air attack. After the first attacks, aircraft were distributed throughout the Top End along access roads at satellite fields. Extensive inland strategic fuel depots were also built.

When the tide of war turned and Germany came under sustained 24-hour air attack, the limitations of fixed airbases became apparent, and the Germans attempted to design a number of air defence capabilities that were not dependent on airbases. These included the Messerschmitt Me 163, which could take off from grass strips and land on a skid, and the Bachem Ba 349 Natter, an even more radical vertical launch design using rocket propulsion. However, none of these technologies translated to mainstream air power design post-war.

Second Generation Airbases

The years following the Second World War found the world with an increased number of aerodromes, although many have since returned to the desert, jungle, or farms in Europe. The cost of building aerodromes had been paid for by a world war, and the fundamental design of major runways and tarmac, services and facilities had been established. The only significant further changes to civil airports have been the surface length and strength and surface movement efficiencies, such as high-speed exit ramps, parallel taxiways and increased parking aprons.

Airbases have followed the 'form-fit-function' of airport runways, and this design remains an inescapable legacy of heavyweight, high-performance aircraft. Air and ground services, maintenance facilities and opportunist commercial entities have remained, but the form-fit-function of the airbase and airport has changed little. Even the onset of the Cold War and the risk of air strikes, including nuclear, chemical and biological threats, did not see significant redesign apart from an increased focus on camouflage, hardening of infrastructure, dispersal and redundancy. The Cold War prompted experiments in aircraft design to reduce dependency on runways, such as the Hawker Harrier and its derivative, the AV-8B. However, these designs suffered from poor range, low speed and limited ordnance capacity and were at high risk of ground-based air defence. The introduction of the F-35 Joint Strike Fighter (JSF) Short Take-off and Vertical Landing (STOVL) variant will reintroduce this capability, in limited numbers, to some Western air forces (**Figure 4**). However, they have not become the predominant design of modern military strike and fighter aircraft.

Figure 4. F-35B JSF STOVL. (Source: Lockheed Martin, 2012)

The Threat

The new threat to Australian and indeed all modern airbases is the arrival of medium-range ballistic missiles (MRBM) and hypersonic weapons, particularly those delivered as a sub-munition of a ballistic missile launch platform. This is a high-end threat associated with high-level conflict. However, an ever-present threat remains from ground-based incursion or, more recently, drone and swarming drone attacks below the threshold of high-level conflict, exemplified by the attack on the Saudi Abqaiq oil refineries (Hellyer et al., 2019) and the conflict in Ukraine.

Some nations in Eastern Europe and others closer to home (e.g., Singapore) have adopted a range of strategies to protect against threats, including hardened structures and deeply buried critical infrastructure; camouflage; dispersal; and multi-layer resilience and redundancy due to dual-use tarmac surfaces using roads and fields. However, all have retained conventional airbases for peacetime and essential maintenance functions. Dual-use facilities have been explored within Australia, particularly by the Royal Flying Doctor Service, where hardened and widened highways are used as contingency runways.

The introduction of precision-penetrating weapons, demonstrated during the wars against Iraq, has reduced the effectiveness of hardened infrastructure, other than deeply buried infrastructure, which is limited by function and cost. Camouflage has undergone several iterations and is arguably of lesser significance due to the introduction of multi-spectral imaging and Global Positioning System targeted weapons.

Untethered Air Operations and Stripped Airbases

Untethering air operations[3] from traditional airbases has attracted some attention in aircraft design. The most obvious examples are the previously mentioned Hawker Harrier and the Russian Federation YAK-38 Forger. These aircraft were designed to operate as Vertical Short Take-Off and Landing aircraft that could operate independently of airbases. Except for the F-35B, the design concept has not been widely embraced; the nature of the design limits the range, payload and performance of more conventional aircraft.

In stripping the remainder of airbase services and support elements, the question has to be asked, what additional risks does this impose? Critical personnel are at heightened risk outside a perimeter. Communication nodes are equally at risk of a cyber attack or air attack irrespective of location, and major maintenance of a flying service done remotely is simply impractical. Nonetheless, airbases can be stripped to the absolute minimum as long as air forces fly fixed-wing, high-performance aircraft; the combination of aerodynamics and liquid fuel engines seriously constrain 'untethering' air operations from the 'concrete' components of airbases. The demand for level, clear and hardened surfaces of adequate length remains essential to allow the take-off and landing of high-performance or heavyweight aircraft.

In any attempt to untether air operations or strip airbase services, redesign must acknowledge the threats mentioned earlier and not just counter the most lethal or state-of-the-art weapons. Perhaps there is a need to review the past

[3]Untethered air operations refers to the ability to conduct launch and recovery of aircraft in remote sites independent of fixed runways and/or traditional airbases. These operations may include the employment of Vertical Short Take-Off and Landing aircraft or the use of surfaces other than purpose-built runways.

and return to the future. The original First World War concept was for aircraft construction, assembly and deeper level maintenance to be conducted at a range from threat. Operational airfields had only essential services, but by necessity had to be close to the area of operations and even closer to forward-landing areas. These airfields could be camouflaged, dispersed, redundant and managed at higher risk. However, all options remain demanding of access to rail/road lines of communication for logistic support, the latter being a past, present and future limitation to Australian air operations.

Recommendations

Any plan to untether air operations from airbases or strip the airbase to its absolute minimum demands testing of assumptions, reviewing lessons and understanding the immutable functional demands on design and concept. Specific recommendations are that:

1. Threats to military air operations must be addressed against a risk matrix of likelihood and consequence. This is not a new premise to risk assessment.
2. Military airbase design, capable of supporting heavy and high-performance aircraft, will demand long, hardened pavements for both current and future forces. However, lighter airlifts and smaller unmanned aerial vehicles have a smaller footprint.
3. Base support needs to be assessed as to its essentiality, frequency of demand, redundancy and whether, in removing it from within a current base perimeter, will not pose as a higher risk of asymmetric or ground-based attack.
4. One size does not fit all. Lessons from earlier conflicts support a 'Defence in Depth' posture. In the First World War, airbases were aircraft parks, aerodromes and forward-landing fields. In the Second World War, dispersal and redundancy became important, as did placing deep-level maintenance and logistic hubs at range from the threat.
5. Airbases should not be designed from a template but instead scaled to purpose. Any disaggregation of current airbases needs to consider all drivers, including:
   - What is the primary purpose (to defend, strike, lift or perform surveillance/reconnaissance)?
   - What are the locational (and environmental) constraints (including range, essential supporting infrastructure and logistics)?
   - What is the spectrum of risk (most likely, most dangerous)?
   - What are the opportunities (in particular extant/alternate infrastructure)?

Conclusion

In the century of airbase evolution, the predominant driver has been logistic support to air operations and aircraft design, not the threat of air attack. The design response to air attacks has been camouflage, hardening and dispersal, but generally within a protected base perimeter, which is demanded by security, counterinsurgency and conventional ground threats.

The arrival of MRBM and hypersonic munitions is an emerging high-level threat to airbases, but arguably all essential infrastructure, and must be considered in the spectrum of extant threats, accounting for likelihood and consequence. Accurate, kinetic attack is not a new threat – the change is in range and speed (reduction in warning time). Response to air strike demands layered responses. Counterstrike has ultimately been a preferred response.

Multiple threats remain to air operations, most of which are outside the perimeter wire of extant airbases. Stripping the airbase or setting-up untethered air operations remotely (e.g., a forward-operating base) may – in the longer term – only add to the risk to critical enablers, including logistics, supply chains, networks and personnel. The lesson from grey zone competition and conflict is that opponents of advanced capability networked forces do not need to, and are unlikely to, initiate first strike kinetic attack. Rather, the lesson from the history of manoeuvre is that the attack will be disruptive by asymmetry. The greatest risk to Australia's capability is not kinetic first strike but interdiction of critical supplies (exemplified by the assured supply of liquid fuel), accompanied by cyber attack, which is as likely to be aimed at civil critical networks and infrastructure as military targets, and attack on critical personnel. Targeted killing of key personnel has become normalised in recent conflicts, often by Western and Western-aligned forces. The Taliban most recently exhibited this strategy with the assassination of Afghan Air Force pilots.

Manoeuvre throughout the history of conflict points to asymmetry as the greatest threat. When considering future airbase design and any policy for stripping extant airbases, a comprehensive risk assessment must be the first, and not last, point of investigation. In the century of airbases to date, air attack has not been the predominant (most likely) threat, and nor is it likely to be in the future; as increased dependencies evolve with advanced technologies, the ever-increasing reliance on data and networks, and the basic needs of life support and force protection of personnel.

References

Defence Images. (2022, July 15). Embarkation sea phase RIMPAC 2022 [Photograph series]. Australian Government, Department of Defence. http://images.defence.gov.au/S20221586

Great War Aviation Society. (2022). The aircraft depot. Cross & Cockade International. https://www.crossandcockade.com/StOmer/TheAircraftDepot.asp

Hellyer, M. M., Millar, D. & Ruser, N. (2019, September 18). What the strike on Saudi Arabia's oil facilities teaches us. The Strategist. https://www.aspistrategist.org.au/what-the-strike-on-saudi-arabias-oil-facilities-teaches-us/

Imperial War Museum. (n.d.-a). The Royal Flying Corps on the Western Front, 1914-1918 (Cat. No. Q 12062, produced 3 July 1918) [Photograph]. https://www.iwm.org.uk/collections/item/object/205247599

Imperial War Museum. (n.d.-b). The Royal Flying Corps on the Western Front, 1914-1918 (Cat. No. Q 12051, produced 21 June 1918) [Photograph]. https://www.iwm.org.uk/collections/item/object/205195250

Imperial War Museum. (n.d.-c). Aircraft of the Royal Air Force 1939-1945: Vickers Wellesley (Cat. No. MH 135) [Photograph]. https://www.iwm.org.uk/collections/item/object/205126828

International Civil Aviation Organization. (2018). Annex 14 Aerodromes: Volume 1 Aerodrome design and operations.

Lockheed Martin. (2022). The F-35B: First descent. https://www.lockheedmartin.com/en-us/news/features/history/f35b.html

Royal Air Force. (1937). RAF pocket book 1937. Air Ministry.

Tedeschi, D. (2019, June). Crash in the Canary Islands. Smithsonian Magazine. https://www.smithsonianmag.com/air-space-magazine/reviews-crash-in-canary-islands-180972227/

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