Article

And if Deterrence Fails? The Case for Qualitative Edge and Combat Mass in a 21st Century Air Force

By Wing Commander Ben Durham

Biography: Wing Commander Ben Durham is a fighter pilot with operational experience on the Typhoon and F-22 Raptor. He led the UK F-35 tactics development and is currently responsible for low-cost un-crewed air systems and payload development in the RAF Rapid Capabilities Office. He holds an MA in Defence Studies from King's College London and an MSc in Aerosystems from Staffordshire University.

Abstract: Strategic competition is intensifying, rapid technological change is eroding conventional military advantage, and deterrence is becoming increasingly difficult. Consequently, states must continue to prepare for inter-state warfare and peer-conflict. This paper examines the debate surrounding the future character of air warfare and makes an argument for a suitable balance of both qualitative edge and combat mass in a 21st Century Air Force. However, many barriers exist for achieving an optimum balance, including prohibitive cost, and competing strategic priorities. It concludes that the UK has chosen not to maximise its potential air power capability, to deliver other strategic objectives. In this context, what constitutes 'enough' capability is difficult to define. However, if deterrence fails, only time will tell if the UK's air power capability proves to be 'enough'.

Introduction

The requirement for an agile and effective force balance remains as important today as at any time in history; the world is characterised by volatility, uncertainty, complexity, and ambiguity.[1] Strategic competition is intensifying, rapid technological change is eroding conventional military advantage, and the COVID-19 pandemic re-emphasised the importance of strategic self-sufficiency. Furthermore, deterrence is becoming increasingly difficult due to a re-balancing of global power, and a blurring of the distinction between war and peace. Consequently, states must continue to prepare for state-on-state warfare.[2]

This paper will examine the debate surrounding the future character of air warfare and make an argument for a suitable balance of both qualitative edge and combat mass in a 21st Century Air Force. It will consider the present-day out to 2040, beyond which, analytical accuracy becomes increasingly difficult due to growing uncertainty. Moreover, whilst space and cyber power are both critical to modern warfare, and often employed by air forces, conceptual precision will be maintained by focusing exclusively on the requirement and ability of an air force to deliver air power. The analysis in this paper will be anchored on Western perspectives, notably, those of the UK, the United States (US), and Australia.

The paper will first examine the anatomy of air power and the evolution of air power theory to deduce an enduring nature and ever shifting character of air warfare and argue that lasting fundamentals define a requirement for balanced, integrated, air power capability. It will then apply the concept of 'Fighting Power'[3] to the Operation Desert Storm air campaign to unpack the constituent parts of air power capability and analyse the relationship between qualitative edge and combat mass. It will next identify emerging technologies and analyse the impact they may have on the future character of air warfare, arguing that the optimum force balance for all possible outcomes is prohibitively expensive; therefore, difficult choices must be made in future force design. Finally, it will conduct a critical assessment of the RAF's future acquisition choices, making comparison to the approach taken by the Royal Australian Air Force (RAAF), which has similar operational air power capability objectives to the RAF.

This paper will demonstrate that the theoretical case for a balance of qualitative edge and combat mass in a 21st Century Air Force can be proven through the deduction of an enduring nature of air warfare, the likely future character of air warfare, and the increased potential for state-on-state conflict. However, many barriers exist for achieving the optimum balance, including prohibitive cost, and competing grand strategic objectives. It will conclude that the UK has chosen not to maximise its potential air power capability, to deliver other strategic objectives as part of a broader grand strategy. In this context, what constitutes 'enough' capability is difficult to define. However, if deterrence fails, only time will tell if the UK's planned air power capability proves to be 'enough.'

Strategic Context

For the previous 30 years, the UK, alongside Western Allies, has fought discretionary conflicts against comparatively weak enemies.[4] The strategic costs of achieving objectives in conflicts against Serbia, Libya, Iraq, al-Qaeda and its affiliates, and most recently the Islamic State, were anticipated to be affordably low by political decision-makers.[5] Yet, strategic competition is intensifying; non-discretionary conflicts with great powers such as Russia or China are increasingly possible. The likely high cost of achieving objectives in conflict against these states makes the avoidance of conflict extremely desirable. Therefore, deterrence remains key to national strategy. However, effective deterrence must be underpinned by capability and credibility.

Powers must maintain military capability and credibility relative to the strategic context. Furthermore, should deterrence fail, states must be prepared militarily, and politically, to coerce through compellence; deterrence is not a tool to offset a lack of capability through 'bluffing.' A 21st Century RAF must, therefore, be prepared to contribute to national and coalition operations, integrated with other domains, across the continuum of competition, both below and above the threshold of armed conflict. Some argue that the true roots of deterrence theory can be found in early air power theory.[6] It is fitting, therefore, that the task of modern coercion falls very heavily, although not exclusively, to air forces.[7]

War in the Third Dimension: the *raison d'être* of a 21st Century Air Force

Although air power is not exclusively delivered by air forces, war in the third dimension is the *raison d'être* of a 21st Century Air Force. The air environment presents unique challenges for warfighting. The physics associated with the air environment complicate aircraft operation and physiological performance.[8] However, the distinctive characteristics of the air environment also provide air power with unique strengths when compared to land or maritime power.[9] These strengths are captured by air power's attributes, which are defined in UK doctrine as height, speed, reach, agility, and ubiquity.[10] When combined, these attributes provide access to targets or points of interest across all levels of warfare, and produce air power's inherent characteristic of flexibility; air power is an extremely responsive and scalable tool.[11] The unique characteristics of the operating environment, however, also shape air power's limitations. These limitations are broadly accepted to be impermanence, limited payload, fragility, cost, and dependency.[12] Similar to air power's attributes, these limitations are relative rather than absolute, and must be understood in that context; limitations may be offset by close co-ordination with other components, or new developments in technology. To understand how an air component delivers effect, we must explore the core roles of air power.

Air power's core roles initially emerged during the First World War and remain valid today. Current UK doctrine defines these roles as: control of the air; intelligence, surveillance and reconnaissance (ISR); attack; and air mobility.[13] Control of the air is, perhaps, the most important air power role, securing freedom of action in the air domain and freedom of manoeuvre in the land and maritime domains.[14] Therefore, securing and maintaining control of the air is a primary

concern for a 21st Century Air Force.[15] It is not, however, an end in itself but a means to an end, setting the conditions for other effects to be delivered.[16] ISR can be considered the first role of military aviation, tracing its roots to artillery spotting during the First World War.[17] In the modern operating environment, information and situational awareness is crucial for the successful accomplishment of objectives at all levels of warfare. Attack operations lie at the heart of the use of air power to influence the behaviour of actors or a course of events, and air mobility was the least employed air power role in the First World War, however, it was proven in the Second World War to be of vital importance, and this importance endures today.[18]

The core air power roles are conceptually and doctrinally endorsed and validated through history. However, they do not fully describe how air power can be so effective. The air power roles explain what air power can do; yet there is a requirement to create synergy across the roles and with other domains. This is the responsibility of air command and control (C2).[19] Air C2, at both tactical and operational levels, is a decisive factor in the application of air power.[20] It is not an air power role but underpins delivery of the four core roles. The importance of air C2 is only increasing in the context of the complex contemporary operating environment and the development of Multi-Domain Integration (MDI).[21] This complexity is partly induced by air power's intrinsic relationship with technology; military advantage is dependent on cutting-edge technology and innovation. Indeed, air capability involves the interplay of 'science, technology, invention…requirements…economics…and industrial practice.'[22] The requirement to maintain a comparative advantage in the air domain has led to a cyclical process of measure-countermeasure that has lasted from the fabric bi-planes of the First World War through to the modern fifth generation fighters of today.[23]

As technology evolves, so does air power thinking and application. By the end of the First World War, the core air power roles were established, and the future potential of air power had been observed. The paper that led to the creation of the RAF, 'The Smuts Report,' suggested, '… there is absolutely no limit to its [air power's] independent use'.[24] Air power theory emerged during the inter-war years, from visionaries such as Giulio Douhet, Billy Mitchell, and Marshal of the Royal Air Force Hugh Trenchard who were strong advocates of the independent use of air power, particularly strategic bombing. They argued that air power could provide such levels of destruction that nations would not go to war against other nations who were equipped with strategic bomber forces.[25] The concept of deterrence through offensive air power was appealing to many who hoped to avoid a repeat of the bloodshed endured during the First World War.[26] Should deterrence fail, it was assumed that bombing could cause such disruption that capitulation was inevitable.[27] Therefore, the prospect of air attack also identified the importance of control of the air.[28] The theories, however, were developed with very little empirical evidence.[29] Furthermore, a backdrop of inter-service rivalry, and justification for independent air services, prevented a reasoned and balanced analysis, leading to an inflated narrative of air power's potential. Additionally, the theories were limited by the technology of the time. However, rapid technological advancement in the lead up to the Second World War provided an initial opportunity to put theory into practice.

Air power's use in the Second World War provided much needed empirical evidence to analyse air power application and effectiveness. All four air power roles were exercised with the importance of control of the air confirmed.[30] Furthermore, the requirement to win the air war at sea was evidenced, as was the effectiveness of integrating air power with land forces for combined manoeuvre.[31] Yet, the hopes of the early air power visionaries, that air power alone would deliver victory, were not realised. Nonetheless, whilst the effectiveness of allied strategic bombing is still contested, the Combined Bomber Offensive (CBO) in Europe did set the conditions for victory, demonstrating the contribution that air power can make as part of a broader, joint campaign.[32] The most compelling lesson, therefore, to emerge from air power application in the Second World War was that there are no absolutes in the effectiveness of air power, and that the greatest effects can be achieved when air power is successfully integrated with other components. Another key lesson was that the delineation between 'strategic' air power and 'tactical' air power is not useful in the debate surrounding air power application or effectiveness. Heavy bombers, often considered 'strategic' in nature, could deliver decisive tactical effects. Similarly, 'tactical' air assets could deliver strategic effect. This lesson, however, was obscured by the impact of nuclear weapons.

Early Cold War air power thinking centred on the concepts of nuclear strategy and neglected to capture key lessons from the Second World War. This manifested in the misuse and, therefore, limited effectiveness of air power in the Vietnam conflict.[33] The decade after Vietnam saw a revolution in the understanding and application of air power, driven by rapid developments not just in technology, but also tactics and training.[34] The re-emergence of air power thinking, in both John Boyd and John Warden, highlighted that it wasn't just nuclear weapons that made air power strategic. Boyd's 'enemy as a complex and adaptive system' and Warden's 'five rings' theories shaped the design and execution of the subsequent effects-based Desert Storm air campaign of Gulf War One.[35] Following Desert Storm, attention largely focused on how stealth and precision enabled overwhelming success, leading some air power advocates to argue that the early air power theories had now met reality.[36] However, others highlighted how air power wasn't independently decisive, but set the conditions for victory on the ground, reinforcing the lessons of the Second World War.[37] Nevertheless, air power became a strategic 'weapon of choice' in the 1990s, offering relatively low risk and low collateral options to decision-makers through the means of precision and survivability.[38]

Air power thinking flourished in the 1990s with Robert Pape, David Deptula, Phillip Meilinger, Eliot Cohen, and Richard Hallion all contributing to the debate.[39] 9/11 and the counter-insurgency wars that followed once again highlighted the limitations of air power as an independent instrument, but emphasised its potential contribution to joint effects.[40] Today, air power remains an instrument of choice; yet, its misapplication would likely result in defeat in modern conflict, thereby reinforcing the importance of a solid grounding in air power theory and history.[41] This grounding also provides an understanding of the fundamentals that shape the enduring nature and shifting character of air warfare.

An examination of the anatomy of air power, and the evolution of air power theory allows us to identify enduring principles that form the nature of air warfare, whilst also observing the variables that influence shifts in an evolving character of air warfare. The nature of air warfare is dominated by complexity, yet four fundamental principles can be deduced: first, an enduring requirement to secure control of the air; second; air power's ability to deliver effects across all levels of warfare; third, that air power is best leveraged as part of a joint campaign; and finally, the character of air warfare is shaped by the measure-counter-measure cycle. Each principle, and its meaning for a 21st Century Air Force, will now be explored further.

The freedom of manoeuvre that western militaries have enjoyed in operations since 1991 has the potential to mask an enduring tenet of air warfare: a degree of control of the air is vital to all air operations, and to the success of operations on the surface. This is particularly true in an era when deployable forces are small, and freedom of manoeuvre is challenged by Anti-Access Area-Denial (A2AD) capabilities. Furthermore, when fighting under near 'parity' conditions, such as a peer-to-peer conflict, control of the air takes on even more critical importance to prevent constraint on all other military operations.[42] The current strategic context highlights that peer-to-peer conflict is increasingly possible. Therefore, the ability to secure control of the air is a fundamental requirement for a 21st Century Air Force.

History shows a tendency for air power to be viewed in absolutes, such as the 'strategic air power' narratives in the inter-war years and the early Cold War era. Air power is a powerful offensive weapon, and it is true that air power can have strategic effect, however, a more nuanced analysis illustrates that air power has the potential to have effects at all levels of warfare, using any or all of the core roles or missions. Therefore, depending on context, all types of air power can be strategic, or any type of air power could be redundant – as demonstrated by the non-combatant evacuation operation in Afghanistan in 2021. Delivering strategic effect requires understanding of many complex elements, and the capability to apply air power appropriately.[43] Therefore, a 21st Century Air Force must ensure balanced capability across the four core air power roles, and the enabling C2 functions, to be able to apply the right air power effect, depending upon the context of the time.

Furthermore, it is seldom the case in history that air power alone has delivered decisive effects, particularly at the strategic level. Air power is empirically proven to be most effective when co-operating with other components as part of an integrated, joint campaign.[44] Even where air power has been operated independently, the application of air power effects to influence activity in other domains, such as the CBO's effect on the fighting power of Germany's land forces, has ultimately provided the most decisive strategic outcomes.[45] In the strategic context of this paper, air power will remain a vital enabler for operations of surface forces, providing effects such as protection from air attack or rapid mobility that cannot be acquired through other mediums.[46] Therefore, a 21st Century Air Force must be capable of integrating effectively with other joint, and combined, components to deliver air power effects in support of overall campaign objectives.

Air power's intrinsic relationship with technology shapes the final aspect of air warfare's nature: the measure-countermeasure cycle. Cutting-edge technology is vital to air power and has been throughout air power's history. Air power application is shaped by relative advantage gained through technological superiority. However, as nations seek to counter relative advantage, the measure-countermeasure cycle occurs. This cycle shapes the character of air warfare. For a period after the end of the Cold War, western air forces enjoyed dominance of the air and information environments largely enabled by stealth, precision, advanced sensors, and networked communications. However, as the cycle continues, superiority in these fields is then challenged. Rapid technological growth and mass proliferation is narrowing western air forces' comparative technological advantage. Therefore, a 21st Century Air Force must be prepared to exploit emerging technological advances to achieve or maintain a degree of relative advantage over potential adversaries.

The character of air warfare is constantly evolving and is driven by the strategic context of the operating environment and the technology of the time. Apparent successes may lead commentators or observers to draw conclusions on the nature of air warfare that are, in fact, hostage to the character of a particular conflict. Indeed, the exact circumstances that prevailed in past or even current operations may not be replicated in future conflicts, therefore, lessons drawn from those conflicts must be seen in that context.[47] Today's character of air warfare is defined by stealth, precision, and information dominance which, when coupled with air power's attributes enables delivery of effects in ways the early air power visionaries could not have predicted.[48] However, proliferation of A2AD systems, and rapid technological growth, means this character will evolve.

Although air power is not exclusively delivered by air forces, delivering air power is the *raison d'être* of a 21st Century Air Force. An air force must be able to fight for and win control of the air to support other military operations. Additionally, it must ensure balanced capability across the four air power roles, to apply the right air power effect in space and time, based upon context. Furthermore, it must be capable of delivering effects in support of overall campaign objectives through co-operation and integration with other components. Finally, it must exploit emerging technology to achieve or maintain a comparative advantage over potential adversaries. Only by delivering this balanced, integrated capability can air forces compete across the continuum of competition to deter or, if necessary, compel potential adversaries. Qualitative edge, however, is more than aircraft and sensors; vital ingredients include doctrine, concepts, tactics, training, leadership, and operator proficiency.

Fighting Power: a measure of qualitative edge and relative mass

'Fighting Power' will be used as a vehicle for analysis of air power capability as this framework provides a wide aperture for analysing what is a complex and broad subject. Fighting power defines the ability of a nation or force to fight, and consists of the conceptual component, which is the process of thought; the moral component, which captures the ability to get people to fight; and the physical component, the means to fight.[49] In the context of air power

capability, 'Fighting Power' provides a framework to understand the importance of doctrinal concepts and operator proficiency when measuring the comparative advantage gained through technology. This is demonstrated by US air power in Operation Desert Storm. This case study was selected because of the common narrative that a technological leap enabled such a conclusive victory in 1991.[50] Commentators laboured the decisiveness of stealth and precision guided munitions (PGMs) on the outcome of the campaign. However, a more nuanced analysis suggests that a paradigm shift in US Air Force (USAF) doctrine and training post-Vietnam was also a key contributor to the air campaign's overwhelming success. This hypothesis will now be explored further.[51]

A key doctrinal development employed during Desert Storm was the implementation of a Joint Force Air Component Commander to design and execute a coherent, joint air campaign plan at the operational level, enabling integrated, synergistic air effects from all air arms and forces, which had a significant impact on the success of the campaign.[52] A further doctrinal development was the use of 'tactical' aircraft for 'strategic' bombing, which was a departure from previous air power thinking and application; the survivability of fighter aircraft, coupled with the ability to deliver precision effects, redefined the concept of 'strategic air power,' delivering decisive outcomes.[53] This survivability, however, was not simply a consequence of stealth, it was also a product of tactics and training; pilots in Desert Storm were '...better trained and better prepared to meet the threat than they were in Vietnam'.[54] The effects of this paradigm shift in tactics and training was also evidenced through increased lethality. Although PGMs received much attention in the aftermath of the campaign, they accounted for less than five per cent of air-to-surface weapons employed;[55] precision *effects* were delivered mostly with unguided munitions, enabled by effective tactics and training. This lethality also translated across to counter-air missions; tactics honed in the decade after Vietnam resulted in a 33:1 kill ratio.[56] There is no doubt that stealth and PGMs had a profound impact on the outcome of the Desert Storm air campaign; indeed, F-117s employing PGMs that could penetrate hardened facilities delivered vital effects.[57] However, these effects must be viewed as part of a broader, joint, and integrated air campaign where qualitative edge was achieved through the sum of all three components of fighting power, not by technology alone. Furthermore, F-117 sorties accounted for less than two per cent of the overall campaign air activity; Vietnam era aircraft such as the F-111 and F-4 flew many more sorties than the F-117.[58] The Desert Storm air campaign, therefore, also highlighted the fundamental relationship between qualitative edge, and combat mass.

The concept of combat mass is relative. What constitutes 'enough' mass depends on the desired effects. Most importantly, the measure of *sufficient* mass is achievement of desired air power effects, not achievement of a desired output. For example, the number of sorties flown, or weapons employed are a poor indicator of sufficient mass for a given objective. An effect-based measure, such as the number of targets struck with desired outcomes, is more suitable; if the required targets are struck, with desired weapons effects achieved, then there was sufficient mass, irrespective of the number of sorties flown. Therefore, precision, and the access provided by stealth, has a significant impact on the concept of mass.

The leverage of stealth and precision on the concept of mass is illustrated by the successful attack of 28 targets by 20 F-117 aircraft, compared to that of just one target by a package of 41 non-stealth aircraft on the same night in Desert Storm.[59] For those attacks, a single F-117 delivered the same relative effects as 19 non-stealth aircraft. This concept of relative mass is further illustrated by the fact that, although the F-117 flew less than 2 per cent of the air campaign sorties, it accounted for over 40 per cent of the fixed targets struck.[60] Therefore, the comparative advantage gained by exquisite technology such as stealth, has the potential to offset a lack of total mass in combat air platforms, particularly in a contested air environment; which is a key consideration for a 21st Century Air Force. Relative mass can also be increased through force multiplication, agility, or interoperability.

When desired effects are used as a measure of sufficient mass, amplifying or increasing effects through third party platforms can increase relative mass. This may be done through force multiplication, such as Air-to-Air Refuelling (AAR); agility, such as multi-role platforms; or interoperability, such as network targeting. For example, if persistent fighter coverage is required as part of a broader operation, the use of AAR can significantly improve relative mass by reducing the overall number of fighter aircraft required. Similarly, the agility of multi-role aircraft has the potential to increase relative mass as they can switch between different mission sets, or, depending on context, carry out different missions simultaneously. Finally, interoperability can improve relative mass by turning a linear, platform-centric kill-chain into an 'any-sensor-any-shooter' kill-web.[61] Therefore, generating the optimum balance between qualitative edge and combat mass goes beyond the procurement of sufficient combat air platforms. Combat support platforms, such as ISR, C2, and AAR aircraft all contribute the relative mass of combat air platforms. This is also true of capabilities in other domains, such as air defence destroyers and satellite-enabled communications.

Qualitative edge and combat mass are intrinsically linked. Qualitative edge is dependent upon exquisite technology, yet that technology is often expensive and, therefore, limited in numbers. Consequently, sufficient mass is required from more affordable capabilities, as was evidenced in the fighter aircraft force balance for Desert Storm. Furthermore, mass alone without qualitative edge doesn't guarantee success, which was illustrated by the inability of the US to deliver decisive air power effects in Vietnam, even at the tactical level.[62] Technology, such as stealth and precision, coupled with combat support assets, such as AAR and ISR, can significantly increase 'relative mass'. However, unlocking the potential of that technology and effectively integrating the combat support assets requires balance across the components of Fighting Power. Therefore, doctrine, tactics, training, and culture must underpin technological edge. Additionally, there is still a requirement for adequate numbers of aircraft and supporting infrastructure to generate critical mass: the minimum relative mass required for credible deterrence or desired air power effects, accounting for expected attrition. This reinforces the importance of air power enablers such as Force Protection, air logistics and engineering. Predicting the appropriate balance of qualitative edge and combat mass requires an understanding of the expected operating environment.

The Future Character of Air Warfare

The perils of prediction are well documented in future war literature; trend spotting is easy yet making sense of those trends and drawing suitable deductions or conclusions is more challenging.[63] However, trend analysis remains crucial for understanding future war.[64] Indeed, the difficulty of prediction does not remove its necessity. Michael Howard suggested that 'No matter how clearly one thinks, it is impossible to anticipate precisely the character of future conflict. The key is to not be so far off the mark that it becomes impossible to adjust once that character is revealed.'[65] Therefore, for the purposes of determining the future balance of qualitative edge and combat mass in a 21st Century Air Force, the ambition should be to get the big things right; in the future, all things are possible, yet they are not all equally probable.[66]

In terms of air power, predicting the future requires the ability to look beyond present norms; things that are apparently impossible for one generation become everyday norms for the next.[67] Deptula suggests, '…if we can learn anything from air power's relatively short history, it should be that air power's potential is limited only by our vision and our willingness to advance'.[68] Therefore, this paper will not presume to predict the exact details of the future character of air warfare. Instead, it will identify the emerging technologies that are likely to influence the air domain before analysing the impact these developments may have on air warfare's character.

The US and its Western Allies face the prospect of losing their long-held superiority in advanced weapons systems. Therefore, the US is pursuing decisive advantage through several emerging technologies, which are likely to change the character of air warfare. Furthermore, the way they plan to field these technologies has evolved. Large, complex programs risk obsolescence before full production; therefore, spiral development will be more agile and faster to field, creating more frequent shifts in the character of warfare.[69] This approach is evident in the development methods for the B-21 Raider and Next Generation Air Defence (NGAD), both of which will exploit digital design concepts and software enabled rapid upgrades.[70] However, the impacts of next generation strike and air dominance platforms on the future character of air warfare are relatively easy to predict. Therefore, it is the other emerging technologies that are likely to have the most profound effect. Including, but not limited to, hypersonic weapons, an expansion in automation, small uncrewed air systems (sUAS), and directed energy weapons.

The US is leading the world in hypersonic development and is likely to field weapons this decade; however, Russia and China are also testing hypersonic vehicles.[71] The ranges and speeds that hypersonic weapons can travel will fundamentally alter the character of air warfare, particularly challenging air and missile defence capabilities. Automation will enable air forces to field mixed fleets of crewed and un-crewed combat air platforms, which are also likely to benefit from significantly increased range and advanced sensors due to nano-technology.[72] Indeed, the combination of automation and nano-technology may significantly offset the air power limitations of impermanence and limited payload. Remotely piloted aircraft systems

(RPAS) and sUAS are likely to become ever more capable, and more prolific. However, they will remain vulnerable to A2AD systems and electronic warfare.[73] Yet, these vulnerabilities may be offset by autonomy, which would alleviate the requirement for human operators, and by stealth or mass. Stealth RPAS will be expensive, but more survivable in a contested air environment, whilst low cost sUAS may carry a variety of kinetic or non-kinetic payloads and be manufactured and procured in great numbers, offsetting attrition. Additionally, potential advances in network capabilities will create opportunity for swarm tactics, where multiple sUAS work synergistically to deliver combined effects. Finally, directed energy weapons could offset payload limitations of air platforms by providing a weapon system with theoretically unlimited fires, in addition to improving air defence capabilities.[74] All of these developments could be leveraged and synergised by the advances that artificial intelligence (AI) could bring to bear for air C2.[75] Whilst it is impossible to say exactly how these emerging technologies will impact the future character of air warfare, it is possible to draw some broad deductions.

Adversary warfighting potential, particularly that of Russia and China, will continue to grow.[76] Therefore, countering A2AD capabilities will remain crucial in future air warfare.[77] In this endeavour, range and standoff will be as valuable as stealth and precision. Freedom of manoeuvre in the air domain will need to be continuously fought for and maintained. This will require integration of all components, combining exquisite technologies such as fifth or sixth generation fighter aircraft, mass provided through un-crewed combat air or low-cost sUAS, and disrupting effects from other domains such as space and cyber. Air forces must expect to be contested in all domains, including the cyber and electromagnetic domain, requiring an increased reliance on autonomy or AI to aid decision-making and C2. Proliferation of RPAS, sUAS, and cruise missiles will likely make operating bases harder to defend, requiring robust air defence, as well as agility and resilience. Furthermore, robust digital infrastructure, ISR and C2 will become ever more important to ensure dominance in the 'sense-understand-orchestrate' cycle of MDI.[78] Long-range RPAS with advanced sensors could provide pivotal operational advantage whilst operating below the threshold of armed conflict. This dramatic shift in the character of air warfare will have a significant impact on the appropriate force design for a 21st Century Air Force. Indeed, winning a peer-to-peer conflict will likely require the application of 'fifth-generation air warfare,' exploiting networks and information to achieve comparative advantage.[79] However, as history suggests, the next generation of air warfare is still unlikely to change the core air power roles, or the demand signal for an air component to support a full range of military activities both at home and abroad.

Technological overmatch will remain essential for power projection and defence of vital assets in future air warfare. Indeed, fifth-generation air warfare requires a fifth-generation air force, which has been defined as '…a fully-networked force that exploits the combat-multiplier effect of a readily available, integrated, and shared battlespace picture to deliver lethal and non-lethal air power'.[80] Yet, this overmatch faces many potential challenges. Most notably, sufficient research and development funding; growth in the complexity, cost and time that is inherent to advanced projects and capability development; and rapid technological change,

fiscal constraint, and global unpredictability.[81] Maintaining sufficient balance against the unpredictable is the most obvious measure to avoid being unable to adapt to the next conflict. However, it is also the most expensive. The optimum balance of both qualitative edge and combat mass is a luxury few can afford.

Achieving the Balance

Ambition and affordability must be balanced to deliver credible air power.[82] Ensuring maximum effect for minimum cost is essential for optimising capability, however, strategic culture and broader political considerations may impact or create tensions in capability acquisition. This section will conduct a limited analysis of the RAF's planned force structure as defined in the 2021 command paper, paying particular attention to combat air platforms and enabling capabilities.[83]

Defence policy is shaped by strategic culture, which defines the requirements, funding, and parameters for the development and fielding of military capability.[84] UK defence and security policy identifies the importance of the UK's relationship with the US, and what contributions the UK can make to collective security across the spectrum of defence capability.[85] In this context, US expectations are a key aspect of setting requirements; it is likely that the US are willing to accept a degree of operational risk in UK air power capability, offset by the UK's political support.[86] Another key consideration for UK capability acquisition is the government-military-industry nexus. This nexus creates tension between pure defence capability aspirations and government prosperity objectives. Whilst Defence views value for money as 'cost-per-effect',[87] the government has a broader aperture that includes economic growth, employment, and technological skills. Furthermore, sovereign capabilities provide freedom of choice on both operational employment and future upgrade programmes. Therefore, a balance must be struck in capability acquisition between what may constitute 'enough' capability sourced domestically, versus 'desired' capability sourced internationally.

Strategic culture further influences capability planning in the form of an accepted, or expected, 'way of war'. In the US, a particular 'war of war' has emerged, which includes 'technological romanticism' and an aversion for casualties.[88] These traits can be extrapolated to the strategic culture of many western nations, including the UK.[89] The biggest challenge for the UK in maintaining this way of war is resource, the US way of war is increasingly expensive and potentially unaffordable for most other nations.[90] Indeed, the USAF is the only air force that can afford to develop and sustain a 'full service' air force that carries out all roles and missions through true global reach and power projection.[91] One method of maximising warfighting capability is to align technology with the US, pursuing a strategy of international procurement that reduces development costs and harnesses the US' research and development power. This approach also improves interoperability and sustainability and is evidenced by Australia's strategy for developing a fifth-generation air force.[92] However, this approach is not compatible with broader UK grand strategy, which includes maintaining the defence industrial base, becoming a global science and technology superpower, and maximising sovereign self-

sufficiency and strategic choice. Therefore, the UK has a much more difficult problem to solve when balancing future force design. This is reflected in the RAF structure and force design articulated in the 2021 command paper.[93]

For combat air, the command paper was preceded by the UK Combat Air Strategy, which set the strategic vision for UK combat air acquisition.[94] The strategy argues an important case for sovereign capabilities to ensure freedom of choice on employment and future upgrades, and also articulates the economic value of investment in UK defence industries.[95] However, it makes little acknowledgement of the capability trade-offs and risks that may come with sovereign capability. Furthermore, it states that F-35B, the Short-Take-Off-Vertical-Landing variant of F-35, will make up the combat air force, alongside Typhoon. This is due to the requirement to operate F-35 from the Queen Elizabeth Class carriers. Yet, multiple commentators note the F-35B's compromised operational performance compared with the land-based F-35A.[96] The UK has initially committed to buy 48 F-35Bs, with 35 due for delivery by the end of 2022, and a long-term program ambition of 138.[97] UK combat air capability will be further complemented in future by the platforms associated with the Future Combat Air System (FCAS); including the Tempest optionally-crewed fighter; Lightweight Affordable Novel Combat Aircraft (LANCA), autonomous aircraft concept; and swarming drones.[98] However, this ambition is potentially unaffordable; even with a significant increase in funding, it is unlikely the UK could afford both the full program ambition of 138 F-35, and also a full-scale effort to replace Typhoon with FCAS.[99] Therefore, difficult decisions will have to be made.

In terms of pure combat air capability out to 2040, the most effective capability solution could be to purchase as many of the originally intended 138 F-35s, as fast as the budget will allow. This would provide the lowest cost-per-effect, whilst also maximising capability, interoperability with key allies, and sustainability. Furthermore, changing the intended purchase to F-35As once the initial 48 F-35Bs required for carrier-strike are delivered would improve the UK's ability to strike with precision over long ranges, whilst also reducing unit and operating costs.[100] Indeed, when coupled with planned upgrades to Typhoon, and LANCA, a large fleet of F-35A and F-35B would provide a potent balance of combat air qualitative edge and combat mass. This force structure would be very similar to Australia's planned force of EF-18G, F-35A, and the un-crewed Boeing Airpower Teaming System.[101] However, whilst this solution would arguably maximise pure combat air capability, short-term operational gain would come at long-term strategic cost, particularly to UK prosperity objectives and combat air solutions beyond 2040. Therefore, it is likely that the UK will sensibly reduce the final total of F-35s to 60-80 aircraft, to afford the FCAS program.[102]

The ambition of FCAS is commendable; the digital design, sixth generation, system-of-systems approach could deliver significant capability, with the advantages of sovereign ownership. Delivered as planned, it could offer a competitive advantage for UK combat air. However, history has shown the risks associated with not delivering on optimistic ambitions regarding future capability;[103] Project Mosquito, a technical demonstrator for the LANCA

programme, was cancelled in July 2022.[104] Should any aspect of FCAS not deliver on time, or with the required capability, commentators suggest the RAF could find itself operationally ineffective in a peer-to-peer conflict in the 2030 timeframe; Bronk argues that a smaller fleet of F-35B would not provide sufficient critical mass to generate required effects, even with additional mass provided by Typhoon.[105] This analysis, however, assumes unilateral, high-intensity, state-on-state warfare, which doesn't account for the strategic context of likely coalition operations. In this context, a more nuanced deduction would be that the UK only needs enough combat air capability to credibly contribute to a coalition. Yet, some observers still suggest planned combat air capability will fall short of this target.[106] Against this backdrop, increasing relative mass through critical enablers such as the E-7 Wedgetail, MQ-9B Protector, and AAR becomes even more important.

Integration, both within the air component and with other components, is the key to unlocking the potential of a fifth-generation air force. Combat air platforms will be severely hampered without the layered effects of ISR and air C2, supported by the force projection capabilities of AAR. Therefore, it is a cause for concern that the UK will only procure three E-7 Wedgetail C2 aircraft; the E-7 adds significant qualitative edge to a modern air force, however, three airframes are unlikely to provide critical mass for desired air C2 effects.[107] MQ-9B Protector is another valuable addition to the UK inventory, and will provide essential capabilities across the continuum of competition, especially below the threshold of armed conflict. However, a planned reduction in air mobility assets, and a lack of sovereign 'boom' AAR capability, will impact the UK's ability to deliver balanced air power across the four core roles, particularly in support of other components. This imbalance of suitably integrated and supported air power is further highlighted by the UK's carrier strike operating model; F-35 is a highly capable platform, yet, its potential is extremely limited without mass provided from Typhoon, and support from C2, ISR, and AAR platforms.[108] The coalition cruise missile strikes against Syria in 2018 demonstrated the critical mass and force balance required for a single air attack when faced with a modern IADS.[109] Therefore, the UK's planned Full Operating Capability of 24 F-35Bs for the UK carrier strike group, without other supporting air assets, is unlikely to harness the full potential of the platform. Indeed, even if the UK mastered the tactics, training, concepts, and technical interoperability of its air assets, which is a significant challenge, evidence suggests the force balance is not optimised for delivering air power effects across the continuum of competition, particularly warfighting with a peer adversary. Whilst not optimised for operational effect, whether this balance is appropriate depends upon strategic aspirations.

The RAF and the RAAF have very similar operational capability aspirations; both air forces aspire to be a next-generation air force, capable of delivering effects across the continuum of competition, in the face of peer adversaries, and alongside key allies such as the US. Yet, the analysis in this section shows the RAAF have a much more robust and deliverable air capability plan, exploiting an optimised balance of qualitative edge and combat mass. Despite similar aspirations, the difference in UK and Australian strategic cultures has driven considerably different acquisition plans. Australia has a limited industrial base, and air power underpins

their national defence strategy.[110] Furthermore, with arguably less global influence than the UK, capability makes a more important contribution to Australia's strategic relationship with the US. For the UK, the desire to maintain a defence industrial base and offer a full spectrum of defence capabilities to a US led coalition has shaped acquisition decisions that aren't optimised for air power effects but are instead balanced for grand strategy. The net result is a higher 'cost-per-effect' and an overall reduction in both qualitative edge and combat mass. However, to pursue an Australian-style acquisition strategy, the UK would have to take risk on other aspects of grand strategy. Increasing F-35 mass at the cost of FCAS delivery could have a significant impact on 'Global Britain,' reducing the UK's strategic self-sufficiency, and impacting defence industry, exports, and employment, without substantially enhancing the UK's strategic relationship with the US. Consequently, a net-gain in air power capability for the UK would likely result in a severe net-loss for grand strategy. Furthermore, capability risk can be offset through coalition integration, particularly with the US. Therefore, strategically, the UK's operational and tactical air power capability risk is balanced by grand strategic gain.

Despite these factors, the strategic narrative surrounding future UK air power capability remains upbeat.[111] However, such narratives are often used to create an impression of leading-edge capability, in the absence of the appropriate investment in the platforms, personnel, tactics, and training that are required to actually deliver that capability.[112] This narrative for the UK has arguably become more important than the capability itself, whereas for Australia, their capability is the air power narrative. In the broader context of strategic deterrence, there is merit to the UK's approach; air power is just one component of the UK's strategic deterrence, which is further amplified by collective deterrence alongside allies. Yet, deterrence can fail, and 'bluffing' is not a tool to offset a lack of capability. This returns us to the question posed at the beginning of this section: how much is 'enough' capability?

Whilst the UK government has had the luxury to only partake in discretionary conflicts since the end of the Cold War, the strategic context suggests a peer conflict of necessity is increasingly likely. Whilst the US, as the likely coalition leader for any such conflict, may accept some operational risk in UK air power, it is still likely to expect meaningful contribution to an air campaign. In a modern peer-to-peer conflict during the next two decades, could the UK have just enough capability to effectively contribute to a coalition, or, as some commentators suggest, would it be '…outgunned, outranged and operationally ineffective…' whilst still being inefficient and expensive?[113] The answer to this question will only become apparent if UK air power is tested in anger. Irrespective of the answer, the UK has chosen not to maximise its potential air power capability to deliver other strategic objectives as part of a broader grand strategy, resulting in an RAF force structure that is not optimised through a balance of qualitative edge and combat mass.

Conclusion

The requirement for an agile and effective balance of qualitative edge and combat mass is as pertinent today as at any time in history. Yet, ambition and affordability must be balanced,

and many barriers exist for achieving the optimum force structure, including prohibitive cost and competing strategic objectives. The strategic context for a 21st Century Air Force is rapidly evolving; a shifting global balance of power and accelerated technological change are contributing to persistent strategic competition. Furthermore, COVID-19 has re-emphasised the importance of sovereignty, and sharpened the focus on budgetary constraints.

UK national security policy highlights the requirement to operate and fight, alongside allies and partners, and across the continuum of competition, to deter and respond to state threats. Deterrence, however, is not assured. Deterrence requires credibility in the eyes of those being deterred and can fail for many reasons. Should deterrence fail, a 21st Century Air Force must be prepared to achieve mastery of the air. A study of air power theory reminds us that air power application must not be limited to prescriptive interpretations and permits the deduction of an enduring nature of air power. As such, we can deduce that a 21st Century Air Force must be organised, trained and equipped to fight for, and win control of the air. Additionally, it must ensure balanced capability across the four air power roles to apply the right air power effect in space and time, and it must be capable of delivering air power effects in support of overall campaign objectives through co-operation and integration with other components. Finally, it must exploit emerging technological advances to achieve or maintain a comparative advantage over potential adversaries. Only by delivering this balanced, integrated, capability can air forces effectively compete in the continuum of competition to deter or, if necessary, compel potential adversaries.

Air power capability goes beyond platforms, sensors, and weapons. Qualitative edge is delivered by harnessing all three components of fighting power, integrating exquisite technology with doctrine, tactics, training, and sufficient combat mass. Mass is a relative term, 'relative mass' can be increased through stealth and precision, force multiplication, and integration. However, there is still a need for a minimum number of airframes and supporting infrastructure to generate the critical mass required for credible deterrence or desired air power effects. What constitutes sufficient mass is relative to the operating context, which is contingent upon the shifting character of warfare.

The future character of air warfare will be influenced by emerging technology that is likely to make the operating environment ever more complex and contested. Whilst the nature and core roles of air power are likely to endure, technological overmatch in the air environment will be essential, enabling the execution of 'fifth-generation air warfare'. Yet, the inherent cost and difficulty of developing advanced capability, coupled with fiscal constraint and rapid technological change, presents significant challenges for achieving this overmatch. Few nations can afford, or even technologically achieve, the optimum balance of both qualitative edge and combat mass. Therefore, tough procurement decisions must be made.

UK Defence requirements are defined by its unique strategic culture. Security policy identifies the importance of the UK's strategic relationship with the US and, as such, US expectations are

key for defining requirements. The US is likely to accept risk in the UK's operational capability, providing it is offset with UK strategic backing and political support. Aligning the UK's air power procurement with the US would provide the lowest 'cost-per-effect', maximise capability, minimise technological risk, and improve interoperability. This approach is evident in Australia's air power capability strategy. However, this approach is not compatible with UK grand strategy, which emphasises the importance of sustaining the defence industrial base, becoming a global science and technology superpower, and maximising sovereign self-sufficiency and strategic choice. Consequently, optimising the force structure is a much more difficult problem for the UK than Australia; exquisite sovereign capability development comes at increased cost and potential delivery risk.

Evidence in this paper suggests that the UK's future force choices have not optimised the ability to deliver air power effects across the continuum of competition, particularly warfighting with a peer adversary. The net result is a higher 'cost-per-effect' and an overall reduction in both qualitative edge and combat mass. Yet, analysis conducted on pure air power capability often neglects to consider wider strategic implications; an acquisition strategy optimised for air power effect could have a significant impact on 'Global Britain.' Indeed, a net-gain in air power capability for the UK would likely result in a net-loss for grand strategy. Furthermore, air power capability risk can be offset through coalition integration. Additionally, air power is just one element of the UK's strategic deterrence, which is further augmented by collective deterrence alongside allies and partners. In this capacity, the UK is still expected to provide a meaningful contribution to US led coalition air power. Should deterrence succeed, a case could be argued that the RAF has achieved the right balance of qualitative edge and combat mass to support national strategic objectives. Yet, if deterrence fails, only time will tell if the UK's air warfighting capability is 'enough'.

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