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Maximising the Utility of the British Army's Combat Aviation

Jack Watling and Justin Bronk

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Executive Summary

THE BRITISH ARMY has reorganised its attack and reconnaissance helicopter fleets into a combat aviation brigade. This paper assesses the utility and viability of this structure and its implications for UK forces. It charts how, historically, demands on aviation have invariably outstripped the helicopters available and employment in conflict has often shifted significantly during fighting. Aviation formations have proven adaptable to these threat environments. However, the formations' aviation supports often become increasingly dependent. Furthermore, in the UK's case, the fact that aviation has been force generated by an operational-level command in Joint Helicopter Command without a tactical command structure has prevented aviation from pushing back on being overcommitted.

This paper assesses the threat level against aviation in great power competition as high and increasing. Aviation can remain survivable and effective on the modern battlefield, but must be able to use dedicated reconnaissance and intelligence to plan missions that bypass enemy defences and use terrain to approach targets undetected. The need to be able to set the conditions for success means that aviation is better employed as a supported manoeuvre element, rather than in small detatchments supporting other formations. The aforementioned dependency generated by the alternate approach forces aviation to engage in sub-optimal conditions, when it becomes vulnerable in higher-threat environments.

Another factor in favour of massing combat aviation is that it is able to independently inflict significant levels of attrition on adversary forces before they get into the close battle, thereby easing the pressure on close combat forces. This is a unique capability within the British Army. Whereas a pair of Apache attack helicopters can unleash a limited volume of up to 32 anti-tank guided missiles (ATGMs) – insufficient to halt a major enemy formation – a battlegroup can deliver up to 256, which could cripple a target formation. Beyond the damage caused, the knowledge that such a concentrated and lethal force is on the battlefield also promises to have a significant shaping effect on the adversary.

In order to realise the potential of a combat aviation formation, the UK must adequately resource the force and ensure its modernisation. It is therefore recommended that the UK:

- Secures a sufficient stockpile of munitions for 1 Aviation Brigade, both by procuring ATGMs and by relaxing the overly cautious flight hour restrictions which currently mean existing munitions are disposed of while still perfectly serviceable.
- Provides 1 Aviation Brigade with an organic logistics battalion.
- Ensures that UK combat aviation has a robust digital backbone by equipping its Wildcat helicopters with Link 16 datalinks.
- Procures Seaspray radar for the Army Wildcat fleet to enable the brigade to conduct relevant standoff reconnaissance to plan and execute independent operations.

- Advances through spiral development experimentation and testing of uncrewed ISTAR and loitering munitions to work in teams with the AH-64E Apache fleet.
- Secures more specialist fuel bowsers for forward refuelling operations, which are in critically short supply.

While the formation of 1 Aviation Brigade is justified by the threat environment and offers UK commanders a highly effective deep strike capability, grouping aviation into a supported manoeuvre element exposes vulnerability in – and creates requirements for – the rest of the force.

First, if aviation is operating in the deep, then the British Army will find that it is – as currently constituted – desperately short of anti-tank firepower in its close combat forces. This was already a glaring weakness in the force, but will become more obvious without the crutch of assuming omnipresent Apache supporting detachments.

Second, the division and corps will need to provide force protection engineering and have air and missile defence in place to protect the main support base for the combat aviation brigade. Other manoeuvre brigades will also need to exercise with 1 Aviation Brigade forward arming and refuelling points embedded within their brigade support groups.

Third, defence planners will need to carefully judge when to deploy aviation assets. Since 1 Aviation Brigade will be mounting independent operations, battlegroups could be committed in competition. Deploying smaller units of action from a battlegroup would, by contrast, complicate the regrouping of that formation to redeploy elsewhere. In a deterrence context, there is also the question of whether to deploy early or late. To deploy early would increase the lethality of early-entry forces, but also risks losing the aviation brigade if the enemy escalated quickly. To deploy late would leave the UK's rapidly deployable forces without teeth. An important question is whether force protection and air defence could be provided by allies to enable the aviation force to enter theatre before major UK combat units.

In short, the formation of 1 Aviation Brigade appears to be a sensible approach to ensuring the maximum utility of the British Army's combat aviation force. However, it will restrict the number of points of presence that aviation can support and will require the Army to support the formation rather than place constraints on it.

Introduction

IT HAS BEEN a persistent feature of modern conflict that armies find more uses for combat aviation than they have helicopters available.[1] How militaries prioritise the employment of their aviation is therefore important, and that prioritisation must be supported by an appropriate structure of maintenance, planning and logistics. The British Army has recently reorganised its helicopter fleets, grouping them in the newly formed 1 Aviation Brigade.[2] This is a significant transition. In the past, army aviation has been tasked with supporting other elements of the force. As an independent brigade, aviation units will be expected to plan and prosecute their own missions at scale. This paper evaluates the merits of employing combat aviation as an independent manoeuvre formation, and assesses the impact of this change on the wider British Army.

The paper is divided into three chapters. Chapter I starts by examining the history of combat aviation to assess how concepts of employment have translated into practice. From there, it explores how the British Army has employed aviation in the recent past and outlines the advantages and disadvantages that can be derived from the support model. Chapter II outlines the push and pull factors that are driving changes in the organisation of combat aviation in the future operating environment. This includes a detailed examination of the main threats to aviation and how they can be mitigated, to establish how aviation can remain survivable on the future battlefield. Chapter III examines how a combat aviation brigade (CAB) might optimally fight in a NATO Article 5 context, as this is the most demanding task for which it might be employed. It then considers what has been assigned to the brigade and whether this structure would be able to fight as outlined. Finally, the chapter looks at the wider impact of these changes on the British Army. The paper also includes an appendix outlining the size, capabilities and projected development of the UK's combat aviation fleets.

Evidence for the paper's conclusions was derived from assessments of systems based on a review of technical publications, visits to manufacturing facilities and observation of exercises by units employing airframes. Concepts of employment were based on a study of operational reports and historical accounts, examination of past and present doctrine, and of future concepts under development in the UK and the US. Analysis of threats and adversary capabilities were based on a combination of data collected from adversary operations, available adversary doctrinal literature, and interviews with analysts, academics and practitioners. With regards to the effectiveness of sensors and munitions, the paper draws on open source literature and battle damage assessments from publicly available data. These were cross-referenced in interviews

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1. 'Aviation' as a term is used throughout this paper to refer to rotary-winged aircraft (helicopters).
2. British Army, 'Army Establishes Its 1st Aviation Brigade', 5 May 2020, <https://www.army.mod.uk/news-and-events/news/2020/05/army-aviation-brigade/>, accessed 6 March 2021.

with subject-matter experts conducted between September 2019 and September 2020 in the US, France and the UK.

While the paper is an assessment of the British Army's combat aviation, it necessarily touches on helicopters operated by the Royal Navy and Royal Air Force. This is because there are operations where helicopters from multiple services must cooperate. Research for this paper included a detailed examination of UK aviation across the services, but its conclusions are focused on the Army. Impacts on Royal Navy or Royal Air Force operations are highlighted, but missions that are exclusively the concern of other services – such as anti-submarine warfare – are not considered.

I. The Evolution of Aviation Concepts of Employment

THIS CHAPTER CONSIDERS how helicopters have, historically, been organised and fought. Its purpose is to identify recurring areas of friction between concepts of employment for aviation and the demands commanders place on these assets in conflict. Although the authors conducted analysis of aviation operations by Russia, India and others, this chapter focuses on the US and the UK.[3]

A Brief History of Combat Aviation Operations

The military employment of aviation began during the Second World War, continuing through the 1940s on an experimental basis. The first combat mission for aviation was an ad hoc rescue of four downed aircrew in Burma in May 1944.[4] Helicopters entered military service as reconnaissance platforms, being deployed to the Korean Peninsula as part of Marine Observation Squadron 6. Their role quickly evolved. During the defence of the Pusan Perimeter, officers found the HO3S-1 helicopter invaluable in enabling commanders to gain situational awareness, while visiting their units to coordinate the defence.[5] Since these early helicopters were shuttling between units, it became common practice to carry supplies, or evacuate injured personnel, while taxiing officers. Aviation was also tasked to recover downed pilots.[6] This early history highlights two recurring trends in aviation employment: the demands on aviation expand beyond the purpose ascribed to aviation units; and from its earliest use, it has had a unique capacity to discretely penetrate enemy-held ground to deliver precise effects or recover specific assets.

The precision with which helicopters could navigate terrain and land, combined with the ability to recover the airframe, resupply forces and evacuate casualties, led the US to see helicopters as superseding the glider as a means of inserting infantry behind enemy lines.[7] For the US Marine Corps, the ability to take off from ships made the helicopter an attractive option for what it dubbed

3. Although development timelines and subtleties of use differ between countries, the evolution of the tasks assigned to aviation are comparable and this study is ultimately concerned with UK aviation, which has been shaped by US thinking and the procurement of US airframes.
4. William T Y'Blood, *Air Commandos Against Japan: Allied Special Operations in World War II Burma* (Annapolis, MD: Naval Institute Press, 2008), p. 116.
5. John C Chapin, *Fire Brigade: U.S. Marines in the Pusan Perimeter* (Quantico, VA: US Marine Corps Historical Center, 2000), p. 28.
6. Charles R Smith, *US Marines in the Korean War* (Washington, DC: US Marine Corps History Division, 2007), p. 722.
7. Nikolaos Theotokis, *Airborne Landing to Air Assault: A History of Military Parachuting* (Barnsley: Pen and Sword, 2020).

'vertical envelopment'.[8] Apart from a small action in the Korean War, it was the British who proved the concept during the 1956 Suez campaign when 45 Commando made the transition from ship to shore via helicopter. However, landing behind the enemy was ruled out because of the risk from ground fire.[9] The US would carry the concept forward with the development of air cavalry, used extensively in the Vietnam War.

The air cavalry concept was effective in inserting troops over a wide area, but the Royal Marines's concern about the vulnerability of helicopters to ground fire was vindicated. During the Vietnam War, almost 2,000 UH-1 'Hueys' were lost to enemy fire, while more than 1,000 fell victim to accidents.[10] The alarming rate at which helicopters were downed by ground fire led to a drive for an escort gunship, which saw the AH-1G Cobra deployed in 1967. It was a successful attack helicopter, with the Soviet Union developing its Mi-24 Hind after observing US attack aviation in Vietnam. As well as chaperoning air cavalry, the AH-1G proved an effective hunter when operating with an OH-6A reconnaissance helicopter.[11] These two forms of independent aviation force – air assault units, whose centres of gravity were the infantry they inserted, sustained and extracted; and attack-reconnaissance units, whose centre of gravity was the attack aviation – both proved viable. Attack aviation was critical to both types of operations, however.

The British had employed helicopters throughout the period of decolonisation, providing support of infantry in the Malayan Emergency,[12] Suez and Aden.[13] By the 1980s, the British had developed several ways of employing aviation. During the 1982 Falklands War, aviation was commanded centrally and employed in dispersed support of operations, proving critical in moving supplies,[14] manoeuvring artillery in preparation for the attacks on Goose Green and the hills surrounding Stanley,[15] and accelerating the advance there through air lift.[16] They were also

8. US Marine Corps, *Amphibious Operations – Employment of Helicopters (Tentative) PHIB-31 NAVMC-4544* (1948).
9. Roy Fullick and Geoffrey Powell, *Suez: The Double War* (London: Hamish Hamilton, 1979).
10. Gary Roush, 'Helicopter Losses During the Vietnam War', Vietnam Helicopter Pilots Association, updated 31 December 2018, <https://www.vhpa.org/heliloss.pdf>, accessed 12 September 2020.
11. David L Porter, *Taking Fire! Memoir of an Aerial Scout in Vietnam* (Jefferson, NC: McFarland, 2020), pp. 64–72; Jonathan Bernstein, *US Army AH-1 Cobra Units in Vietnam* (Oxford: Osprey, 2012), p. 31.
12. Robert Jackson, *The Malayan Emergency & Indonesian Confrontation: The Commonwealth's Wars, 1948–1966* (Barnsley: Pen and Sword, 2011), pp. 95–104.
13. Jonathan Walker, *Aden Insurgency: The Savage War in Yemen 1962–67* (Barnsley: Pen and Sword, 2014), p. 81.
14. Kenneth L Privratsky, *Logistics in the Falklands War: A Case Study in Expeditionary Warfare* (Barnsley: Pen and Sword, 2014), pp. 77, 199.
15. Max Hastings and Simon Jenkins, *The Battle for the Falklands* (London: Pan Macmillan, 2010), pp. 329–30.
16. Lawrence Freedman, *The Official History of the Falklands Campaign, Volume 2: War and Diplomacy* (Abingdon: Routledge, 2004), p. 508.

key to Special Forces operations and the rescuing of crew from British vessels struck by Argentine munitions. Prioritising demands for aviation became a major bottleneck in British operations.[17]

The British Army of the Rhine (BAOR) was supported by several Army Air Corps squadrons operating attack-reconnaissance teams of Gazelle and Lynx helicopters, expected to provide a mobile anti-tank capability in support of ground forces.[18] The BAOR also held 24 Airmobile Brigade as a blocking force with a significant anti-tank capability enabled by helicopters.[19] Nevertheless, the helicopters in both of these latter formations were vulnerable to ground fire (as demonstrated in the Falklands, where enemy light infantry were able to bring down helicopters with small arms). Thus, while potentially valuable as a blocking force, their capacity to penetrate defended territory as densely populated as East Germany had to be doubted.

Those doubts were challenged in 1991 when the US conducted a deep penetration raid on the central radar station of Iraq's integrated air defence system using the AH-64 Apache.[20] The Apache was a critical enabler for the US's AirLand Battle concept during the Cold War, which called for deep penetration of the enemy to defeat the second echelon of Soviet forces.[21] Built with multiple layers of redundancy, the Apache was far more survivable than earlier airframes, while its improved avionics and flight performance enabled nap-of-the-earth (NOE) flight that could pass beneath the notice of most late 20th-century radars. Using aviation in this manner required that they be organised into independent groups operating far ahead of the rest of the force.

A further set of innovations began to change how aviation worked with reconnaissance. During the Vietnam War, the OH-6 had conducted 'reconnaissance' for AH-1 Cobras by flying ahead and drawing fire to reveal enemy positions. The US made significant advances in modern sensors to enable reconnaissance helicopters to find targets first, but the OH-58 Kiowa had a limited ability to penetrate enemy airspace with Apache and was supposed to be replaced with a more suitable aircraft that was subsequently cancelled. Israel took a different approach, having started work

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17. Privratsky, *Logistics in the Falklands War*, p. 141; Tom Martin, *Falklands Gunner: A Day-by-Day Personal Account of the Royal Artillery in the Falklands War* (Barnsley: Pen and Sword, 2017); Robert H Scales, *Firepower in Limited War* (Washington, DC: National Defense University, 1990), pp. 213–14.
18. Tim Ripley, *British Army Aviation in Action* (Barnsley: Pen and Sword, 2011), p. 44.
19. Graham Watson and Richard A Rinaldi, *The British Army in Germany: An Organizational History, 1947–2004* (Tiger Lily Publications, 2005), p. 100; Carl Schulze, *British 24 Airmobile Brigade* (Ramsbury: Crowood, 1999).
20. Smithsonian Channel, 'Actual Footage of Desert Storm's First Apache Strikes', 22 May 2015, <https://www.youtube.com/watch?v=RhpgCaPoBaE>, accessed 27 March 2021; US General Accounting Office, 'Operation Desert Storm: Apache Helicopter Was Considered Effective in Combat, But Reliability Problems Persist', GAO/NSIAD-92-146, April 1992, <https://www.gao.gov/assets/160/151734.pdf>, accessed 12 September 2020.
21. US Army Training and Doctrine Command (TRADOC), 'FM 100-5 Operations 1982', 1982.

on observation UAVs in the 1970s.[22] By the 1990s, they were able to maintain a persistent UAV presence feeding live video to a command post, with the ability to designate targets. Thus, Israeli Apaches no longer needed to expose themselves to engage targets, but could guide munitions in from beyond line of sight, putting the UAV in harm's way. This was demonstrated on 16 February 1992 when Israel assassinated then general secretary of Hizbullah, Abbas Al-Musawi, designating his vehicle with a UAV, while Apaches fired missiles from a safe distance.[23] This was the start of a journey that today is pushing the boundaries of advanced teaming between crewed helicopters and uncrewed platforms. The optimal relationship between reconnaissance aviation, attack aviation and UAVs, however, remains an open question, since most experimentation has been done in the relatively permissive airspaces of the War on Terror.

The performance of the Apache in the early 1990s piqued the interest of the British Army, which successfully procured a modified version of the AH-64D in 1995.[24] As the Apache was delivered, the British Army conducted studies of how to most effectively employ its aviation, concluding that grouping it as a strike element would maximise its battlefield effect.[25] Although the concept of an aviation manoeuvre element had traction within the Army, this was not adopted. At the time, there was a drive to establish joint organisations wherever possible. As the peace dividend from the Cold War saw cuts to the size of the force, grouping aviation into a joint structure also allowed a smaller overall helicopter fleet to theoretically support more of the force. Deploying aviation as support elements also appeared to better service the need to respond to multiple stabilisation and humanitarian contingencies in a context where there was a reduced risk of great power war. The 1998 Strategic Defence Review therefore recommended the formation of Joint Helicopter Command (JHC).[26]

22. John F Kreis, 'Unmanned Aircraft in Israeli Air Operations', *Air Power History* (Vol. 37, No. 4, Winter 1990), pp. 46–50.
23. Ronen Bergman, *Rise and Kill First: The Secret History of Israel's Targeted Assassinations* (New York, NY: Random House, 2018), pp. 382–97.
24. National Audit Office, 'Building an Air Manoeuvre Capability: The Introduction of the Apache Helicopter', 31 October 2002, <https://www.nao.org.uk/wp-content/uploads/2002/10/01021246.pdf>, accessed 12 September 2020.
25. Directorate General of Development and Doctrine, *D/DGD&D/1/109/LW2: Towards an Air Manoeuvre Formation* (Upavon: Ministry of Defence, 1996).
26. Ministry of Defence (MoD), 'Strategic Defence Review', July 1998, para. 97.

Joint Helicopter Command: Impact on the Force

The 1998 Strategic Defence Review argued that:

> the support helicopter plays a crucial role in virtually all today's military operations. Its importance in providing tactical mobility and flexibility is likely to grow, especially when the Apache attack helicopter enters service. Although our support helicopters are already used very flexibly, to achieve maximum operational effectiveness we have decided to bring together all our battlefield helicopters in a single joint command.[27]

JHC was an operational-level command, apportioning aviation 'units of action' from the centralised pool to the UK's various theatres of operation. In theory, by grouping training and deployment of aviation from all three services, this increased the number of aircraft potentially available to support any given mission. Needs had to be balanced between Iraq, Afghanistan, Northern Ireland, Brunei, UK Special Forces and British training areas. From a sustainment point of view, a unit of action comprises at least three helicopters, enabling two to be ready for use at any given time. As a rule of thumb, three units of action must be available to maintain one permanently deployed helicopter, with one working up and another in deep maintenance. Furthermore, the number of units of action available is constrained by the number of deployable maintenance kits and other supporting infrastructure. This was slightly eased in Afghanistan by the scale of combat service support available at Camp Bastion. Units of action could also be enlarged to meet the expectation that aircraft would fly in pairs for protection. With so many concurrent operations, the UK was severely stretched, not only because of the number of airframes available but also by the structure of support and maintenance that was necessary to deploy them.

The air assault on the Al-Faw peninsula, carried out by 3 Commando Brigade at the start of the Iraq War, saw aviation employed en masse to rapidly seize key positions inland, showcasing the capacity for JHC to coordinate the deployment of aviation assets across the services.[28] As the campaigns in Iraq and Afghanistan protracted, however, demands for persistent aviation support expanded. This was exacerbated by the tactics fixed on by British commanders. In Afghanistan, the decision to disperse British forces throughout Helmand Province into 'Platoon Houses' resulted in a dependency on aviation for resupply and force protection.[29] British commanders underestimated the ability of the enemy to adapt and threaten ground lines of communication, constraining logistics and manoeuvre.[30] The dependency therefore increased as the density of improvised explosive devices made ground movement perilous. Small British units found

27. *Ibid.*
28. David Kilcullen, *Out of the Mountains: The Coming Age of the Urban Guerrilla* (Oxford: Oxford University Press, 2015), pp. 276–77.
29. Patrick Bishop, *3 Para* (London: Harper Perennial, 2008); *BBC News*, 'UK Troops "Need More Helicopters"', 8 October 2006.
30. Nick Reynolds, 'Learning Tactical and Operational Combat Lessons for High-End Warfighting from Counterinsurgency', *RUSI Journal* (Vol. 164, No. 7, 2019), pp. 42–53.

themselves confronting large enemy forces, requiring close support from air and aviation to maintain initiative. Apache was in particularly high demand. While fast air could provide highly responsive strikes, the longer period during which Apache was on station had a suppressive effect on the Taliban that provided British infantry with an opportunity to manoeuvre. As demands increased, British aviators changed tactics to meet the tempo of operations. Whereas attack aviation normally flew in pairs for mutual protection, given the limited anti-air threat, they were increasingly sent on solo sorties to maximise the number of operations deliverable by the available assets.

Despite these adjustments to aviation tactics, British officers complained that they were short of aviation support.[31] This translated into a political dispute in 2009 after it emerged that the Chief of the General Staff was having to move around Afghanistan in a US helicopter.[32] Later revelations that contractor-operated Mi-8 and Mi-26 were providing logistical support cast further doubt on the government's assurances that the UK maintained a sufficient aviation fleet.[33] This debate was exacerbated by the Army, which was seeking to modernise its medium-lift fleet by securing UH-60 Blackhawks.[34] Nevertheless, it reveals some important aspects of the discussion over aviation as shaped by its dedicated support role. The amount of available aviation increased during the campaign in Afghanistan, yet commanders had pursued a strategy that depended on more than was available.[35] While they may well have asked for more aviation to get them out of this situation, it was a failure of planning that had led them to be in that position of dependence.[36] It is also notable that aviation units successfully adapted to meet the requirements of the force, but because they were tasked to support other units there appears to have been little consideration of whether this rapid adaptation would have more pernicious long-term consequences.

Although the Taliban proved less capable of countering aviation than the Mujahideen had been when fighting the Soviet Union,[37] in both cases dependence on aviation by the wider force fixed such assets to a tempo of sorties that made them predictable. Against a more capable adversary, this could have become a critical vulnerability. As aviation crews became stretched, training and tactics adapted to meet the demand. This led to a degradation of expertise in the Apache force in conducting operations against more capable adversaries. Fortunately for the UK,

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31. Nick Allen and Rosa Prince, 'Shortage of Helicopters Undermining "Protection" of Troops in Afghanistan', *Daily Telegraph*, 16 July 2009.
32. James Downie, 'British Army Chief Has to Borrow American Helicopter', *Foreign Policy*, 15 July 2009.
33. Christopher Leake, 'Now We Are Borrowing Russian Helicopters to Fight the Taliban', *Mail on Sunday*, 18 July 2009.
34. Ned Temko and Mark Townsend, 'MoD Rejected Three Deals to Buy Black Hawk Helicopters', *The Observer*, 19 July 2009.
35. House of Commons Defence Committee, 'Helicopter Capability: Government Response to the Committee's Eleventh Report of Session 2008–09', HC 381, 23 February 2010.
36. Theo Farrell, *Unwinnable: Britain's War in Afghanistan 2001–2014* (Oxford: Bodley Head, 2017).
37. Alan J Kuperman, 'The Stinger Missile and U.S. Intervention in Afghanistan', *Political Science Quarterly* (Vol. 114, No. 2, Summer 1999), pp. 219–63.

when NATO intervened in Libya in 2011, the British Army had enough Apache crews who were trained prior to the changes driven by the campaign in Afghanistan and were able to conduct sorties in support of Libyan opposition forces in a more heavily contested air environment.[38] Operations in Libya were much closer to the deep strikes envisaged in attack aviation doctrine, though they also demanded significant innovation to be launched from the sea as part of a multinational force.

The centralised aviation support model has arguably had a more serious effect on the wider force. Prior to the formation of JHC, many British units had aviation support, but it was confined to those units that held organic aviation elements in their orders of battle, or else was specifically assigned to missions during the planning process, having been delegated from higher echelons.[39] For instance, in the BAOR, aviation was a corps asset and, in exercises, its availability could be determined by a chain of command.[40] However, the centralised pooling of aviation assets under JHC meant that, theoretically, any element of the British Army could find itself the main line of effort, in receipt of massed aviation support.

This has had a number of pernicious effects. The availability of Apache and other aviation support is widely assumed in exercises.[41] 16 Air Assault Brigade's lack of anti-tank capabilities is bought out by attack aviation. Yet, at the same time, attack aviation is supposed to be a critical enabler of the Royal Marines – who are also short of organic anti-armour capabilities. It was also supposed to provide support to the UK's Strike Brigade and be a reserve anti-tank force for 3 (UK) Division. In brigade exercises, a wide range of threats are eliminated by the application of aviation, thereby enabling other units' lack of organic lethality to be ignored, because hard tasks are made someone else's problem. Because JHC is an operational headquarters servicing demand, it was hard to simulate in exercises the decisions as to whether aviation is or is not available to support a particular part of the force. Perhaps more importantly, there was no senior tactical commander, responsible for aviation operations, who could explain the balance of risk in assigning aviation to support competing lines of effort.

By placing few constraints on defence assumptions about the prioritisation of aviation, the JHC model has enabled its availability to be presumed, well beyond the capacity that it holds under command. The UK Apache force is already triple hatted. A further damaging effect of this widespread dependency on aviation among UK forces is that to ensure the viability of other formations, UK helicopters are likely to be required to provide support, even when the environment places aviation at critical risk. Changes in the operating environment are constraining aviation's employment, and the dependency on aviation in other formations is creating a vulnerability in UK formations to dislocation. In short, the flexibility offered by JHC has led to the overcommitment of aviation, or the sizing of aviation fleets to meet fewer missions

38. Will Laidlaw, *Apache Over Libya* (Barnsley: Pen and Sword, 2016).
39. Anthony Farrar-Hockley, *The Army in the Air: The History of the Army Air Corps* (London: Sutton, 1994).
40. Louis Vieux-Bill, 'BAOR Order of Battle: July 1989', <https://www.orbat85.nl/documents/BAOR-July-1989.pdf>, accessed 5 June 2020.
41. Authors' observations of multiple wargames.

than it is expected to perform by virtue of that fleet being theoretically deployable against a wide set of contingencies.

Several conclusions can be drawn from this survey of the historic interaction between concepts of aviation employment and their actual use. It is clear that aviation has very broad utility, meaning its use is often adapted considerably during campaigns. Demand usually expands and outstrips availability. Through JHC, the UK has sought to maximise the flexibility of how it employs its aviation in order to meet the scale and geographically dispersed demands placed on it. However, placing aviation under an operational headquarters while subordinating it tactically to other arms has led to a widespread dependency that diminishes its flexibility. In a higher-threat environment, this dependency could place aviation where it is required by other elements, but cannot protect itself. To judge whether this is the case, it is necessary to consider the threats to aviation and how they can be mitigated.

II. Drivers of Change: Threats and Opportunities

On 24 March 2003, the US Army's 11th Aviation Regiment was tasked with conducting a strike on the Iraqi Republican Guard's Medina Division, west of the city of Karbala.[42] The Iraqis lost a small number of anti-aircraft artillery (AAA) and trucks, but over the course of the 45-minute engagement, the Apaches – coming under fire from small arms and AAA across a wide area of urban terrain – were forced to withdraw.[43] One Apache was downed and its crew captured. Two more were severely damaged, though they managed to escape. A further 27 were damaged with multiple hits per aircraft. The need to replace major components of multiple aircraft saw the 11th Aviation Regiment taken out of action for some time, several of its aircraft requiring over a month to be repaired.[44]

There were many tactical mistakes that helped the Iraqis defeat the 11th Aviation Regiment. Poor coordination between SEAD strikes, combined with imprecise intelligence on targets, led to limited route planning for the approach to the objective, against an adversary that was familiar with aviation tactics and prepared for the specific strike. Iraqi spotters warned the Medina Division of the 11th Aviation Regiment's takeoff from the tactical assembly area. The Iraqis did not possess an advanced military in 2003, and the damage inflicted was by small arms. The US was fortunate not to have more aircraft shot down. The costs of comparable errors against a peer adversary would have been much greater.

The means by which aviation avoids incidents such as the defeat at Karbala are a combination of mission planning, tactics and technical countermeasures designed to limit the aircraft's exposure. Another aviation deep strike mission was carried out four days after the failed raid on Karbala. With better intelligence, coordination and planning, it was largely successful.[45] The takeaway is that, to be effective in warfighting, aviation must have the freedom to create conditions for success. This requires a staff to plan missions and senior representation in higher echelon planning cycles to request support from – and offer support to – the main line of effort. It is also necessary for aviation to be able to alter their techniques to avoid becoming predictable. If assigned to directly support other units, that flexibility is unlikely to be forthcoming, because

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42. Richard J Newman, 'Ambush at Najaf', *Air Force Magazine*, 1 October 2003, <https://www.airforcemag.com/article/1003najaf/>, accessed 15 February 2021.
43. *Ibid.*
44. Jonathan Bernstein, *AH-64 Apache Units of Operations* Enduring Freedom *and* Iraqi Freedom (Oxford: Osprey, 2012), pp. 48–52.
45. P A Gautron, 'Beyond Karbala: The U.S. Army's Approach to Apache Doctrine', Canadian Forces College, 2013, <https://www.cfc.forces.gc.ca/259/290/299/286/gautron.pdf>, accessed 12 September 2020.

aviation support will be required when the supported element is most pressed, rather than when the aviation is best able to deliver effects and evade enemy fire. A good example of this was seen on 2 March 2002, when eight US Army Apaches were assigned to support Operation *Anaconda* in Afghanistan. During the early stages of the operation, one had its electronics destroyed, while two more suffered serious damage. The remaining Apaches fought on but all suffered multiple hits.[46] Six of the eight were unavailable for three days of subsequent operations.[47] The Taliban and Al-Qa'ida fighters had engaged US aviation with a mixture of 12.7mm DShK machine guns and RPGs used as improvised airburst projectiles. Aviators were able to mitigate this vulnerability by flying above the range of the RPGs but remained vulnerable because they were tethered to supporting ground units. This dilemma would be exacerbated against a peer adversary with SAMs, because helicopters would need to stay low.

In providing intimate support, helicopters are forced to fly predictable orbits, which similarly accounted for the downing of UH-60 Blackhawk helicopters by irregular forces over Mogadishu in 1993.[48] The first UH-60 loss might well be attributed to an underestimation of the adversary. But because the aviation support was critical to protecting the ground units, they could not change their posture in response to the increased threat, meaning a second Blackhawk suffered the same fate. Against adversaries with very limited weapons, there are some readily available ways of avoiding these threats, but being fixed in conflict with a peer adversary would likely lead to rapid attrition.

In a renewed era of great power competition, the ability to deter by deploying credible warfighting forces is once again a critical driver of force design.[49] Even if great power war remains unlikely, the competition between great powers makes conflicts against non-state actors and sub-peer adversaries considerably more dangerous, because they are likely to be armed with sophisticated weaponry by competitors.[50] The number of man-portable air defence systems (MANPADS), sensors and communications capabilities in the operating environment is liable to increase.[51]

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46. Richard Kugler, 'Operation *Anaconda* in Afghanistan: A Case Study of Adaptation in Battle', Center for Technology and National Security Policy, National Defense University, 2007, pp. 15–16, <https://apps.dtic.mil/dtic/tr/fulltext/u2/a463075.pdf>, accessed 12 September 2020.
47. Richard L Kugler, Michael Baranick and Hans Binnendijk, 'Operation *Anaconda*: Lessons for Joint Operations', Center for Technology and National Security Policy, National Defense University, March 2009, p. 49, <https://ndupress.ndu.edu/Portals/68/Documents/DefenseTechnologyPapers/DTP-060.pdf?ver=2017-06-22-143027-187>, accessed 12 September 2020.
48. Mark Bowden, *Black Hawk Down* (London: Bantam Press, 2009).
49. Consider, for instance, the emphasis on deterring hostile state actors in successive NATO communiques. See NATO, 'London Declaration', press release, 4 December 2019, <https://www.nato.int/cps/en/natohq/official_texts_171584.htm>, accessed 7 March 2021.
50. John J Mearsheimer, *The Tragedy of Great Power Politics* (New York, NY: W W Norton and Company, 2001).
51. Small Arms Survey, 'New Trend Analysis of Global MANPADS Proliferation', <http://www.smallarmssurvey.org/about-us/highlights/2020/highlight-manpads-proliferation.html>, accessed 15 February 2021.

In a context where a great power competitor is seeking to impose costs, it is also reasonable to assume that they will prioritise supplies of arms to counter the most lethal element of a force, leaving aviation a prime target.[52]

The change in the political context and threat environment has consequently forced a shift in how the British Army has organised its combat aviation. At present, its manoeuvre elements are short of decisive firepower, lack a sufficiently large divisional artillery group and have limited organic lethality – especially against armour.[53] Moreover, while there are some units that could fight enemy armour, capabilities such as the Challenger II main battle tank are best concentrated to achieve effect, and are vulnerable to enemy fires when manoeuvring, so that they cannot act as a blunting force without depleting their readiness for offensive action. There is, therefore, a deficiency in the force in being able to blunt an enemy advance along an unexpected axis, and a limited capacity to offend the enemy in the deep, which is a critical task if the force is to win in the close.

Combat aviation, with a unique combination of manoeuvrability, reach and lethality, can fill this gap in UK force design if massed, providing the divisional or corps commander with a highly potent striking force. As an example, a Russian motor rifle brigade has approximately 40 main battle tanks supporting more than 100 armoured personnel carriers.[54] A pair of Apache supporting a UK manoeuvre element against which this enemy force was concentrated could carry up to 32 anti-tank guided missiles (ATGMs). Assuming a probability of kill (P_k) lower than one, this would be insufficient to halt the enemy manoeuvre element. The pair could also be supressed by the five organic air defence batteries within the Russian brigade.[55] By contrast, a battlegroup of 16 Apache could bear 256 ATGMs, which could overwhelm and suppress the brigade's air defences, and even with a P_k of 0.25 would halt the manoeuvre element. ATGMs have achieved a P_k of 0.7 in Syria,[56] suggesting that the battlegroup could cripple the Russian brigade.

Two primary drivers of change can be observed from the above survey. First, the threat environment requires an increasing capacity to plan and support aviation operations, rather than fix them to supporting the force. Second, the massing of aviation presents an opportunity to deliver highly impactful deep effects. It is important, however, to consider whether aviation is objectively survivable on the modern battlefield.

52. A dynamic demonstrated by the US against Soviet forces in Afghanistan. See Steven Coll, *Ghost Wars: The Secret History of the CIA, Afghanistan and Bin Laden* (London: Penguin, 2005), p. 11.
53. Jack Watling, 'The Future of Fires: Maximising the UK's Tactical and Operational Firepower', *RUSI Occasional Papers* (November 2019).
54. Igor Sutyagin with Justin Bronk, *Russia's New Ground Forces: Capabilities, Limitations and Implications for International Security*, RUSI Whitehall Paper 89 (London: Taylor and Francis, 2017), p. 30.
55. *Ibid.*
56. Jakub Janovský, 'Seven Years of War – Documenting Syrian Rebel Use of Anti-Tank Guided Missiles', *Bellingcat*, 4 May 2018.

Assessing Aviation Survivability

In order to establish whether aviation is sufficiently survivable in the future operating environment, this section details the primary threats to aviation and the mitigations that may be adopted to address them. Ensuring that these mitigations can be adopted constitutes a set of constraints that govern how aviation must be employed, further determining whether aviation is best organised into a manoeuvre element or distributed in support of the force.

Against a state adversary, there are a range of threats that must be considered that have not been a major factor in planning operations during the global War on Terror. Foremost among these are surface-to-air missile systems (SAMs). There are several short-range SAMs specifically designed to counter low-flying helicopters (as well as cruise missiles), of which the most capable is the Russian SA-15 'Tor-M2'. The Tor-M2 has a K-band radar which, much like the Longbow radar of the Apache, has a short range but boasts rapid target acquisition and high resolution for accurate missile guidance. The system can engage up to four targets with eight missiles simultaneously out to 16 km, meaning that it out-ranges the AH-64D/E's current Longbow radar/Hellfire missile combination.[57] It is mounted on a tracked chassis, designed to keep pace with armoured formations over rough terrain, and is a standard component of Russian motor rifle and armoured manoeuvre formation equipment, as well as being deployed as part of layered static or semi-static defences. In addition to its main command radar guidance mode, the Tor-M2 has a backup optical tracking mode to give a graceful degradation of performance in heavy ECM conditions.

At medium ranges, systems such as the Russian SA-17 can engage low-flying targets with semi-active radar guided missiles out to the edge of their radar horizon, which is itself dependent on terrain, target altitude and battery radar placement. However, the latest versions of the SA-17 Buk-M2 and Buk-M3 are reportedly equipped with 9M317A missiles, which have an active radar seeker head to enable reduced P_k engagements of targets outside the direct radar coverage of the launch battery when cued in by elements of a broader integrated air defence system (IADS).[58] In a similar vein, very-long-range SAMs, such as the Russian SA-21 (S-400) and SA-23 (S-300V4) and Chinese HQ-9 series, have a limited radar horizon range in semi-active engagements against very-low-flying targets such as aviation assets flying NOE. However, these systems are starting to gain access to active seeker missiles such as the 40N6 and 9M82MD, which can conduct post-apex lock-on engagements against low-flying targets at long ranges. This assumes the system can be provided with sufficient target data from over-the-horizon or aerial sensors contributing to the IADS picture.[59] Since modern SAM systems

57. To assist with closing this gap, Israel and the US have procured limited quantities of the longer-ranged Spike NLOS missile for use by their Apache fleets. Jen Judson, 'US Army to Field Israeli-Made Long-Range Missile on Helicopters', *Defense News*, 9 January 2020.
58. VPK, 'Зенитная управляемая ракета 9М317' ['9M317 Surface-to-Air Missile'], <https://vpk.name/library/f/9m317.html>, accessed 8 February 2021.
59. For a more detailed discussion, see Justin Bronk, 'Status and Future of Russian A2/AD Capabilities', in Michael Jonsson and Robert Dalsjö (eds), 'Beyond Bursting Bubbles: Understanding the Full Spectrum

are mobile and tend to be operated as part of layered, resilient IADS, suppression/destruction of enemy air defences (SEAD/DEAD) operations in any future state-on-state conflict are likely to take much longer to achieve decisive results, and so aviation will increasingly have to operate sustainably in the presence of such threats. Where terrain, MANPADS and direct fire threats allow, NOE flight and masking techniques should remain highly effective in preventing large-scale casualties from semi-active SAMs among aviation assets. However, if an IADS is being fed sufficiently high-quality information from either over-the-horizon or aerial 'look down' sensors to cue in active seeker missiles with lock-on-after-launch capabilities, then the use of aviation in conspicuously large formations would become a significant risk. Against these threats, it is necessary for aviation to be employed in careful coordination with air assets carrying out the suppression or destruction of SAMs within the area of operations.

This need to synchronise with the air component is further reinforced by the threat of adversary air assets in any state-on-state conflict. The most serious potential high-end threat to aviation is from fixed-wing, look-down/shoot-down systems. Hostile fast jets are the most obvious potential threat. In 1994, a US Air Force F-15C shot down a US Army UH-60 Blackhawk in a friendly fire incident using an AIM-120 AMRAAM while the former was at low level in a valley.[60] This would suggest that with nearly 20 years of technological advancement since then in both radar and seeker technology, rotor-related missile-lock difficulties should not be relied on to keep aviation safe from hostile fighters in the absence of friendly defensive counter air (DCA) cover. Against a modern state opponent, a range of systems from traditional AWACS types such as the Russian A-50M to radar-carrying UAVs like the Chinese Divine Eagle are also likely to be operating behind the coverage of their own ground-based SAM systems. By operating at high altitude with modern PESA or AESA radars, these assets can spot even low-flying targets, such as aviation, against ground clutter from hundreds of kilometres away. The latest upgrades to systems such as the Russian A-50M and Chinese KJ-2000 include greatly enhanced datalink connectivity to enable them to pass high-grade situational awareness and target data to both aerial- and ground-based systems. In conjunction with active radar seeker missiles for SAM units, such assets can greatly enhance the threat that an IADS poses to aviation assets, while being difficult to target by dint of operating significantly behind the forward line of enemy troops (FLET), defended by ground-based SAMs and fighters.

Russian forces can also call on the Mig-31BM Foxhound, which is a huge twin engine, supersonic, high-altitude interceptor designed around a Zaslon-M radar/fire control system and the R-37M missile.[61] The Mig-31BM is distinct from previous versions of the Foxhound in that it has been specifically optimised to share target data with ground-based SAM networks and to detect and

of the Russian A2/AD Threat and Identifying Strategies for Counteraction', FOI, FOI-R—4991—SE, June 2020, pp. 23–40.

60. US General Accounting Office, 'OPERATION *PROVIDE COMFORT*: Review of U.S. Air Force Investigation of Black Hawk Fratricide Incident', November 1997, <https://www.gao.gov/assets/160/156037.pdf>, accessed 9 September 2020.

61. For more information, see Justin Bronk, 'Russian and Chinese Combat Air Trends: Current Capabilities and Future Threat Outlook', *RUSI Whitehall Reports*, 3-20 (October 2020), pp. 26–29.

destroy difficult, low-flying targets such as cruise missiles against heavy ground clutter beyond 100 nautical miles.[62] As such, the Mig-31BM is likely to be ideally suited to hunting aviation operating near a Russian forward line of own troops (FLOT) or within the deep battle area. Therefore, any such aviation operations would need to be accompanied by penetrating offensive counter air (OCA) cover or planned in accordance with intelligence indicating a lack of Foxhound sorties or capacity during the mission window.

One of the most intriguing threats for which there is little data is the potential for engagements against hostile aviation assets, including the Mi-24/35 Hind family, the Mi-28 Havoc and the Ka-52 Alligator. All are heavily armed with cannon, guided and unguided rockets and the option to carry IR-homing air-to-air missiles or MANPADS. In exercises in the US, UK Apache crews have had successes against simulated Russian attack aviation, and there are reasons to believe that the combination of sensors, training, accurate stabilised cannon fire and Hellfire could allow them to counter such threats in an Eastern Europe contingency.[63] On the other hand, the more flexible weapons fit options on Mi-28 and Ka-52 compared to Apache, especially the option to mount large numbers of modern MANPADS on stub wings, means that they cannot be discounted as a threat to aviation manoeuvres near and beyond the FLET.[64] Beyond simulated engagements, there are a lot of real-world unknowns that could affect the outcome of such an encounter.

Minimising exposure to these threats utilising intelligence, route planning to use terrain masking through NOE flight, and coordination with OCA/DCA and SEAD/DEAD operations can all enable aviation to operate in a high-threat environment by reducing the adversary's awareness of aviation activity and their ability to concentrate sensors and assets against it. However, NOE flight significantly increases the risk from threats that have proved dangerous throughout the War on Terror and would be more so in a state-on-state conflict because of their greater prevalence. These threats include AAA, small arms fire and ATGMs, and MANPADS. The UK military's approach to survivability against these threats is layered. The first layer is attempting to remain undetected by the enemy for as much of an operation as possible. If detected, the second includes evasive manoeuvres and countermeasures systems to avoid being hit by enemy fire. If hit, the third consists of retaining enough mechanical and system redundancy and armour protection around personnel and critical points of failure to remain capable of controlled flight. If rendered incapable of controlled flight by hits, the final layer of survivability includes measures such as landing gear shock-absorbing crumple features, crash-rated seats and fire suppression systems to prevent fatalities from a crash landing.[65]

The threat from small arms fire, ATGMs and AAA can be addressed together. Small arms fire is a simple but nonetheless potentially lethal and largely unavoidable danger for aviation in any combat zone. Soldiers will typically fire their weapons – including 0.50-calibre, 12.7mm

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62. Yefim Gordon and Dmitriy Komissarov, *Russian Tactical Aviation Since 2001* (Manchester: Hikoki Publications, 2017), pp. 128–30.
63. Authors' discussions at Army HQ, Andover, 25 June 2020.
64. Authors' discussions with Apache crews, JHC Flying Station Wattisham, 27 July 2020.
65. *Ibid.*

and 14.5mm heavy machine guns, and guided and unguided anti-tank missiles/rockets such as the ubiquitous RPG series – at any enemy helicopter they see. Especially when concealed in woodblocks or urban terrain, troops on the ground can be extremely difficult for aviation crews to spot until they are fired upon. This is a particular risk when conducting tactical troop insertions or reconnaissance/strike teaming sorties where a combination of terrain masking at very low level and periods in the hover or at least very slow rates of lateral movement render helicopters particularly easy targets if they encounter concealed troops.

AAA cannons also pose a serious threat, often being mounted on self-propelled vehicles and guided by radar-assisted targeting systems. Irregular forces in the Middle East employ large numbers of twin-barrelled ZU-23-2 23mm cannons and heavy machine guns in static positions and mounted on vehicles. Against a near-peer or peer opponent, enemy manoeuvre elements and patrols are likely to be equipped with large numbers of vehicle-mounted automatic weapons up to 30mm calibre, often with laser range finding and other aiming assistance measures. The Russian SA-19 'Tunguska' and SA-22 'Pantsir' self-propelled AAA systems are also armed with high-velocity, heat-seeking, radar command guided or optically guided missiles in addition to rapid-firing 30mm cannons.[66] The radar used by these more sophisticated threats does make them more lethal, but also means they are easier to detect and either suppress, kill or evade than non-radar-assisted AAA.

Despite the multiple layers of mechanical and system redundancy built into modern military helicopters, sustained exposure to small arms and particularly heavier-calibre AAA will rapidly result in critical and potentially fatal damage. As a result, a constant lookout by crews and mission planning – making use of the best possible intelligence on hostile force dispositions – is vital for reducing the likelihood of being caught within range of such threats. This includes planning operations to coincide with periods of darkness and/or low-visibility weather conditions wherever possible. When engaged, evasive manoeuvres and getting out of range and the line of fire as quickly as possible are essential. Electronic countermeasures can also help to reduce the threat from more sophisticated radar-assisted AAA systems. While such tactics and equipment can mitigate against the threat of unexpected encounters with hostile AAA and ground fire at close ranges, the risk cannot be fully eliminated, particularly in a NATO context where Russian formations of all sizes can put up a huge volume of heavy-calibre firepower in addition to more specialised AAA assets. Mission planning and tactical situational awareness will be critical to minimising losses of aviation sorties when operating at low level in the combat area. As force densities decrease, it is plausible that missions can be planned to minimise contacts. Massing aviation can also assist in deterring incidental engagements with enemy recce units, given the threat of rapid and accurate retaliation.

MANPADS are a ubiquitous threat that is likely to remain a feature of operations against both irregular forces and near-peer or peer state forces, with more than 500,000 thought to be in

66. *Army Technology*, 'Tunguska M1 Anti-Aircraft System', <https://www.army-technology.com/projects/tunguska/>, accessed 9 September 2020; Missile Threat (CSIS Missile Defense Project), 'Pantsir S-1', <https://missilethreat.csis.org/defsys/pantsir-s-1/>, accessed 30 March 2021.

circulation globally.[67] MANPADS are relatively short-ranged, heat-seeking missiles launched from tubes carried by infantry or sometimes mounted on vehicles. They typically require a period of several seconds to bring to a state of readiness to fire, as the battery pack cools the seeker head. However, once ready to fire they are simple to use. Because MANPADS are passive weapons that do not emit radiation, they cannot generally be detected by helicopters until fired, at which point the onboard missile-approach warning system (MAWS) would detect, classify and track the missile via the heat plume of its rocket motor. The speed of modern MANPADS, coupled with the active and passive evasive tactics and equipment used to reduce their effective engagement window as far as possible, mean that by the time a launch warning has been conveyed to the crews, the onboard countermeasures system has either successfully deflected the missile or the missile has hit.[68] This means that once a missile is in the air, crews are almost completely reliant on the capability of their defensive aids suite (DAS) to detect, identify and automatically release countermeasures in an optimal way to defeat the particular MANPADS which has been fired at them. This in turn places a great deal of reliance on ensuring that the mission data files which control the DAS on UK helicopters are kept up to date and informed by accurate intelligence data on the likely MANPADS threats.

The challenge is increasing, with third-generation systems such as the Russian Igla-S and Chinese FN-6 having greatly improved range and resistance to countermeasures compared to previous generations. The most recent fourth-generation Chinese QW-2/4 MANPADS are equipped with imaging seekers, allowing them to discriminate between the shape of a target aircraft and decoys/countermeasures, rather than simply relying on IR/UV signature.[69] The fourth-generation Russian SA-25 (9K333) Verba is not equipped with an imaging seeker, but does feature a tri-band seeker and can be issued with a helmet sight to cue the operator on to incoming threats that have been detected by other assets.[70] This offers the potential for greatly improved responsiveness against fleeting targets such as helicopters flying NOE by Russian regular or proxy forces. Despite many launches against UK helicopters in Afghanistan, Libya and Iraq in recent years, no losses have occurred as a result of MANPADS, which is a testament to the effectiveness of the DAS, threat intelligence and mission data file refresh process against first-, second- and even in some cases third-generation MANPADS.[71] However, it will be crucial to maintain investment in this enabling capability for the whole aviation force, especially as the fourth generation of Russian and Chinese MANPADS, such as Verba, HN-6 and QW-4, proliferate. Given the increasingly high level of countermeasure resistance in such systems and their use on a large scale by Russian regular and special forces, protection of aviation assets

67. Federation of American Scientists, 'Man-Portable Air Defense System (MANPADS) Proliferation', <https://fas.org/programs/ssp/asmp/MANPADS.html>, accessed 9 September 2020.
68. Authors' discussions with Wildcat crews, RNAS Yeovilton, 13 January 2020.
69. Sean M Zeigler et al., *Acquisition and Use of MANPADS Against Commercial Aviation* (Santa Monica, CA: RAND, December 2019), pp. 5–6.
70. Konstruktorskoye Byuro Mashynostroyeniya (KBM), 'Verba Man-Portable Air-Defence System', <https://www.kbm.ru/en/production/pzrk/803.html>, accessed 9 September 2020.
71. Authors' discussions with Apache and Wildcat crews, JHC Flying Station Wattisham, 27 July 2020; authors' discussions with Wildcat crews, RNAS Yeovilton, 13 January 2020.

against MANPADS in a peer context may require directed infrared countermeasure (DIRCM) systems in addition to more traditional flares. The US Army has mounted a DIRCM system on its AH-64Es in combat zones since 2017 and the UK's 50 airframes are expected to include a similar capability.[72] However, although suitable systems are in operation with multiple allies, most of the UK's current aviation fleets (apart from Merlin HC4) lack DIRCM systems, rendering the threat from advanced MANPADS a significant risk factor except at extremely low altitudes.

In sum, aviation can be survivable, but must have the greatest possible latitude to determine when and how it approaches identified targets. It must also be employed as part of a deliberate planning process rather than in forced response to enemy action. Even the terrain itself suggests that aviation will need to operate independently of other forces. While during the global War on Terror aviation has preferred to fly at medium altitude to decrease the threat of ground fire, the requirement to adopt a NOE profile shapes where and when aviation can manoeuvre. In order to remain masked from enemy radar and other sensors as far as possible, NOE flight profiles emphasise using whatever physical obstructions are available – such as hills, valleys and even woodland – as cover while in flight. Accurate terrain data on the intended flight path, operating area and potential diversion routes are thus critical, and the latest avionics suits on the Wildcat and Chinook HC Mk.5/6 in particular have automatic flightpath-optimisation features, which can use accurate terrain information to give pilots a route to minimise the aircraft's signature from hostile threats. AH-64E is now bringing this capability for the Apache fleet. As such, while rough terrain can potentially be a flight safety threat to low-flying aviation in bad weather or at night, with modern FLIR, night-vision goggles and accurate mapping information a lack of vertical terrain features can actually be a bigger threat.

Finally, perhaps the most basic threat to the continued availability of aviation assets in any conflict is fragile logistics chains. Without a ready supply of spare parts, ammunition and aviation fuel to forward operating bases, aviation rapidly ceases to function. In a COIN operation or intervention against a sub-peer state, this is not a threat, but simply a limiting factor based on available deployable spares kits, national stocks, and contractor and military logistic support networks. Against a peer adversary, however, attacks against logistics convoys and hubs are likely to be one of the easiest ways for an enemy to defeat UK aviation assets. With limited numbers of purpose-designed resupply vehicles, especially Oshkosh fuel tankers, even limited attrition from enemy fires, aviation or special forces would rapidly reduce the ability of UK aviation elements to sustain a high operational tempo from forward operating bases and temporary forward arming and refuelling points (FARPs).[73] Given this vulnerability in a peer-level conflict, therefore, aviation should be considered a *supported* rather than a *supporting* element of the force, for without force protection it will struggle to continue to operate.

72. Joseph Trevithick, 'US Army Hits Setbacks Trying to Add New Infrared Countermeasures to Its Helicopters', *The Warzone*, 25 January 2018.
73. *Ibid.*

III. Employing the Combat Aviation Brigade

ASSESSING THE EFFECTIVENESS of a massed combat aviation force in the land domain requires both an evaluation of the concept and a consideration of whether the resources made available make this realistic. This chapter begins, therefore, by outlining how a CAB might fight in a NATO Article 5 context. Clearly, an aviation brigade could contribute to many more mission sets, but would have greater flexibility in how it did so in lower-threat environments. Focusing on the task of deterring Russia in the European theatre provides the benchmark for the capability.[74]

Combat Aviation in Warfighting

Military manoeuvre comprises the movement of forces to achieve a position of relative advantage against an adversary.[75] Therefore, to be a manoeuvre element, aviation must plan and conduct operations aimed at securing an advantage over the enemy. Within the context of the UK warfighting division, aviation's unique contribution is in lessening the strain on close combat units by attriting enemy forces in the deep, blunting enemy breakthroughs and interdicting supplies. This has been demonstrated in repeated *Warfighter* exercises.[76] While aviation can thus be widely tasked, the raison d'être of the CAB is the conduct of deep strikes against enemy forces not yet in contact. These operations require the penetration of enemy territory. The threat from AAA and non-dedicated small arms fire would constrain such aviation operations to the night, or low-visibility days, unless exceedingly high-fidelity intelligence on enemy dispositions was obtained. Beyond the threat, aviation requires maintenance between sorties,[77] putting it on the ground for a significant portion of the day.

When aviation is on the ground, it is vulnerable to attack. Enemy special reconnaissance actions and deep fires constitute the most direct threat. The most effective mitigation against artillery is the range at which aviation is based. Given that Russian multiple-launch rocket systems (MLRS)

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74. This is the primary threat to the UK identified by the Integrated Review. See HM Government, *Global Britain in a Competitive Age: The Integrated Review of Security, Defence, Development and Foreign Policy,* CP 403 (London: Her Majesty's Stationery Office, March 2021).
75. Land Warfare Development Centre, 'Land Operations', Army Doctrine Publication, AC 71940, 2017, pp. 5:1–5:4.
76. John Mead, 'Winning the Firefight on the "Road to Warfighter"', *British Army Review* (Vol. 175, Summer 2019), p. 70.
77. Marvin N Russell, 'Is the Current Army Aviation Maintenance Strategy Efficient or Effective in the Post Cold War, Non-Linear Battlefield Era of Expeditionary Force Projection?', US Army War College, May 2004, <https://apps.dtic.mil/sti/pdfs/ADA423799.pdf>, accessed 15 February 2021.

can reach to 120 km, though the launchers may be 15 km behind FLET, one may assume aviation to be based at a considerable distance from the FLOT, within the NATO corps air defence zone. This zone should also provide ballistic missile defence (BMD) to reduce the threat from long-range precision fires. This can be further mitigated by force protection engineering with HESCO gabions separating the aircraft, protecting them from mortars, UAVs or direct fire. Enemy special forces can also be deterred by mounting a CAP, as well as other force protection measures such as the use of UAVs and artillery, and having a perimeter defence of the site.

There has been much discussion of dispersing logistics in future operations.[78] While dispersal for protection may be suitable for packets of armour able to mount credible self-defence if engaged, the vulnerability of aviation on the ground, combined with the maintenance required, makes it unrealistic to disperse airframes for a prolonged period. As a reversionary course of action, if the main combat service support (CSS) hub is repositioned, it may be viable for a brief period. However, as a standard operating procedure (SOP), it would lead to attrition of airframes and CSS from enemy special reconnaissance action or hostile penetrating aviation.

Operating from a hub in the corps support area, one can therefore envisage two operations per night per battlegroup, which could be divided into as many as 16 pairs of aircraft or massed. If a nominal combat radius of 180 km is assumed, then from a position 120 km behind the FLOT, these raids could penetrate up to 60 km beyond the FLET. This would, however, reduce depending on the need to traverse the front, the time taken in 'fighting through' or manoeuvring past enemy positions, and in acquiring and identifying the target. The force would therefore need to refuel closer to the FLOT. Given the threat environment, these FARPs would need to be protected, likely located in the brigade support area of the divisional manoeuvre elements. This would enable the aviation units of action to reach the enemy corps deep, depending on opportunities for penetration.

The simultaneous use of FARPs in the brigade support area comes with several additional advantages beyond extending range. Given the need to group aviation at a centralised CSS hub, the takeoff of a large packet of helicopters would undoubtedly be picked up by adversary over-the-horizon radar. Given range limitations, this could be directionally tracked to ascertain the rough axis of advance, which could then allow cueing of additional sensors to support catching the aviation as it penetrated enemy territory. By contrast, if a large force package leaves the CSS hub and then breaks up to reach multiple FARPs, the picture fragments, the timeline is extended and, while the force package could concentrate after refuelling, it would not necessarily do so within a predictable timeframe. Thus, while the adversary would be alert through the night, they would have far less information with which to prioritise their resources for finding, fixing and destroying the aviation elements.

Penetrating enemy territory to strike the deep requires careful mapping of terrain and radar horizons, enemy positions and capabilities, and an appreciation for the boundaries between

78. Mark Baldock, 'Survive First, Sustain Later: Exercising Dispersed Logistics in the Close Fight', *Logistics in War*, 14 March 2017.

enemy units. These will move over the course of operations. Furthermore, most of these factors can only be reliably identified through sustained observation. Although particular ISTAR assets can be accessed and the data they gather analysed quickly, the integration of reconnaissance reports, aerial and satellite surveillance, radar and other forms of analysis mean that it is reasonable to assume missions to be planned over a 72-hour period. This is one reason why having a dedicated brigade staff is critical to successful aviation operations in this environment, because it ensures that a team of experts is able to monitor the environment and conduct essential planning.

In order to mitigate the risks from particularly high-threat Russian capabilities such as airborne warning and control systems and Mig-31BM combat air patrols, large-scale sorties would also need to be coordinated with suppression activities such as OCA/DCA and SEAD sorties conducted by the RAF or other NATO air assets. In the face of extensive Russian electronic warfare (EW), mission crews would need to minimise their communications, again demonstrating the importance of having a dedicated headquarters able to liaise with other elements of the multi-national, multi-domain effort to coordinate activities. Multiple missions could be planned concurrently so that operations could be mounted daily. Much of the information needed to build up a target package would draw on sources external to the CAB. However, some ISTAR would need to sit with the CAB to provide responsive and timely answers to planning questions.

One of the most flexible ISTAR assets organic to the CAB would be its fleet of Wildcat – if they were equipped with Link 16[79] and the Seaspray radar.[80] Planning routes to penetrate enemy-held terrain and identifying large enemy formations manoeuvring in the deep are critical to planning aviation operations. One may envisage Wildcat remaining in orbits above the brigade support area of friendly manoeuvre elements at 5,000 ft, using its radar to identify enemy movement out to 150 km.[81] Over time, this would resolve into recognisable patterns, building up a picture of enemy boundaries and positions.[82] This intelligence would be highly useful in the brigade's planning cycle if integrated with information from higher-echelon and multi-domain ISR. The Wildcats would be visible to the enemy due to long periods spent in orbits at medium altitudes. Therefore, these Wildcat sorties would have to be flown sufficiently far behind the FLOT to remain out of range of medium-range SAMs such as the SA-17, and behind the brigade air defence screen or friendly DCA cover.

79. 'Tactical Data Links' in Myron Hura et al., *Interoperability: A Continuing Challenge in Coalition Air Operations* (Santa Monica, CA: RAND Corporation, 2000).
80. Leonardo, '7500E V2: SeaSpray 7500E V2 AESA Surveillance Radar', 2020, <https://www.leonardocompany.com/documents/20142/3149777/Seaspray+7500E+V2+mm09072.pdf?t=1603120577156>, accessed 15 February 2021.
81. Distance determined by radar range equation. This technique was evaluated and proved highly successful during Exercise *Warfighter*. Authors' interview with 1 Aviation Brigade command team, Middle Wallop, June 2020.
82. The authors had these capabilities demonstrated by Royal Navy aircrew in a land operations context in August 2020. They also received technical briefs at Leonardo Helicopters, 6 August 2020.

The Wildcat could also play an important role in giving the brigade headquarters the ability to support operations in progress. In a heavy EW threat environment, an Apache penetrating enemy positions would not be broadcasting information. However, they could receive information over Link 16 without being detected. In the first instance, Wildcat could pull tactical information from ground units over Bowman and use its ground moving target indication (GMTI) radar to scan for threats and flag them to the Apaches. This would provide the Apaches with situational awareness if hostile forces began to converge on their position, providing lead time for them to avoid, engage or abort. This is particularly important if the Apaches are seeking to minimise their own signature by keeping their radar off as much as possible. If the brigade headquarters became aware of targets from ISR elsewhere in the force, Wildcat could also function as a forward fire controller to help deconflict those fires from the Apaches in the target area.

A further proposed use of Wildcat is as a recce platform in close support of Apache, using its MX15 EO/IR sensor to find and fix targets, or identify threats ahead of the Apache formation.[83] It could also cue in ground-based fires on to identified targets, thereby avoiding giving the enemy awareness of the presence of aviation. In practice, however, the Wildcat has less effective sensors than the Apache and being lightly armed is probably not ideally suited to this role.[84] Furthermore, given the small fleet of Wildcat available, there is a tension between the provision of intimate reconnaissance and standoff attack-reconnaissance teaming using radar. Assuming a single regiment of Wildcat supports the CAB, this would need to generate flights during the day and night – unlike the Apaches – and therefore may struggle to generate enough aircraft to be available for intimate teaming.

There is a need to positively identify (PID) targets prior to engagement, in order to avoid wasting munitions on decoys, striking misidentified targets or revealing aviation's presence without reward. This is especially important if conducting a salvo strike, not least because of the cost of the munitions. One tool that could substantially help to establish PID would be a launchable UAV that would send back electro-optical and/or thermal imaging to its launch aircraft. There is currently no UK programme of record to acquire such a capability, but experimentation with complex payloads are underway in the US,[85] Israel and South Korea.[86] In theory, this could be a fire-and-forget munition, and would enable an Apache strike package to get within firing range and dispatch the UAV to approach the target from a different direction and establish PID. After this, the Apaches could engage with high confidence, without having given away their presence or position, or call in joint effects. This triangulation between standoff GMTI, synthetic-aperture

83. L3Harris, 'WESCAM MX™-15, Air Surveillance and Reconnaissance', <https://www.l3harris.com/all-capabilities/wescam-mxtm-15-air-surveillance-and-reconnaissance>, accessed 15 February 2021.
84. The authors were passengers aboard an attack-reconnaissance sortie demonstrating these techniques in July 2020.
85. Garrett Reim, 'AH-64E Apache Teams With Two UAVs to Identify, Attack Target', *FlightGlobal*, 4 February 2021, <https://www.flightglobal.com/helicopters/ah-64e-apache-teams-with-two-uavs-to-identify-attack-target/142277.article>, accessed 8 March 2021.
86. Seth J Frantzman, 'Korean and Israeli Firms Eye Partnership to Arm Helicopter With Kamikaze Drones', *Defense News*, 5 March 2021.

radar imaging and electro-optical identification would enable the strike package to engage rapidly and decisively.

The balance of munitions used for such a mission would depend on the target, but a battlegroup attack could, as already indicated, launch as many as 256 ATGMs at a target, as well as directing joint effects against targets such as precision artillery from divisional fires assets. In practice, Apaches would likely carry a smaller number of ATGMs. For example, a standard warfighting loadout might comprise eight ATGMs, a 2.75-inch rocket pod and the aforementioned UAV, or auxiliary fuel tank. This still represents a considerable concentration of precise firepower.

Such a formation would give a division or corps commander up to four battlegroup attacks per night, assuming each battlegroup flew two missions, or up to 32 sorties of pairs of Apaches, premised on the same number of sorties per airframe. An additional sortie might be generated, but this capacity may be held in reserve to act as a blunting force in case of an unexpected enemy breakthrough. It would be reasonable to assume that this could be sustained for three days before the force would need a day to recover.

In terms of the effect on an enemy, the more they moved – therefore exposing units to identification – the more options could be targeted, complicating countermeasures. Because of the reach of aviation, the ability to mass concentrated lethality across the battlespace could have a significant cognitive shaping effect on adversary manoeuvre, slowing down movement by imposing laborious defensive procedures to be enacted across the front.[87] If these steps were not taken, then such a force could deliver a devastating level of attrition on enemy units. The effect is magnified when synchronised with other manoeuvre elements. For example, a large-scale aviation strike early in the night could be followed by a ground manoeuvre element's attack, exploiting the damage and disruption in the targeted sector. This would prompt the enemy to begin moving units, revealing their positions and disrupting many defensive tactics such as the placement of decoys or air defence ambush sites, enabling follow-up aviation attacks or the application of long-range precision fires.

The level of lethality brought to bear by a CAB would make its destruction a high priority for the enemy. There would be two serious threats to such a force. The first would be the targeting of its logistical hub by long-range precision fires in a volume able to overwhelm corps' ballistic missile defence (BMD) capabilities, alongside special reconnaissance activities against FARPs and resupply convoys. The second would be the use of airborne sensors, over-the-horizon early warning sensors, and a combination of SAMs and fast air to identify the vector of attack and then interdict the aviation manoeuvre element when it was exposed. Avoiding the latter threat would come down to the fidelity of the intelligence picture, the planning conducted by the brigade staff and the judgement of the CAB commander as to when to commit aviation assets. It would also require a preparedness to call off missions if the threat environment developed in

87. Comparable to the concept of the 'fleet in being'. See Julian Corbett, *Some Principles of Maritime Strategy* (London: Longmans, Green and Company, 1911).

a manner that could risk the loss of a unit. The lethality of attack aviation manoeuvre elements should not obscure its potential vulnerability to rapid degradation in the face of airframe losses.

A further form of CAB employment is in the enablement of air assault operations.[88] This is not an organic capability, since it requires infantry from forces trained and equipped for air assault, and significant shaping of the environment. The organisation of 1 Aviation Brigade and its employment as outlined above does not place air assault operations at the heart of the CAB's expected mission set. There are several reasons for this. As a former senior US officer serving in Germany during the late 1980s observed in an interview, 'there are very limited circumstances that are conducive to effective air assault, and if you optimise your force around that mission then you start to desperately look for missions that are suitable: they can't always be found'.[89] Modelling of aviation assault in modern high-intensity warfare has brought back an expected rate of attrition of 40% of the airframes employed, meaning that it is a 'one-shot tactic' with limited ability to extract, reposition or conduct subsequent operations.[90] The high confidence of this rate of attrition is less a result of the initial insertion than of the need to provide persistent resupply and support to the inserted force, which fixes aviation into predictable routes and time intervals on the battlefield and exposes them to increasing risk. This is different in the Pacific where island hopping across unoccupied atolls is critical to advancing sensors and shooters into contested sea space.[91] However, in Europe, aviation assault is very risky in any high-intensity context. This does not mean that it should not be done when the conditions are right. US Multi-Domain Operations envisage extensive higher-echelon shaping to create openings to enable the penetration of enemy forces and insertion of troops via aviation assault, whether to secure key terrain or destroy high-value targets.[92] If such opportunities present themselves, then the CAB should be able to work with other elements of the force to exploit them. However, given their scarcity, prioritising this mission would be a mistake. The structure therefore prioritises strike by attack aviation supported by reconnaissance aviation, with the Chinooks of the CAB restricted to logistical functions unless an opportunity to insert infantry by aviation appears and offers advantage. In this context, a battlegroup strike mission could instead chaperone the Chinooks to their target area, with Wildcat providing the critical recce function to screen the insertion route for hostile forces.

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88. MoD, 'Joint Doctrine Note 1/20: Air Manoeuvre', June 2020, pp. 99–122, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/895569/20200616-doctrine_uk_air_manoeuvre_jdn_1_20.pdf>, accessed 15 February 2020.
89. Authors' interview with a former senior US officer, Washington, DC, October 2019.
90. Authors' interview with aviation subject-matter experts, Andover, November 2019.
91. 'Expeditionary Advanced Base Operations (EABO) Handbook: Considerations for Force Development and Employment', 1 June 2018, <https://mca-marines.org/wp-content/uploads/Expeditionary-Advanced-Base-Operations-EABO-handbook-1.1.pdf>, accessed 28 March 2021.
92. US Army, 'The US Army in Multi-Domain Operations 2028', TRADOC Pamphlet 525-3-1, 6 December 2018.

1 Aviation Brigade: Force Organisation and Generation

Having examined how the CAB might function as an independent manoeuvre brigade in a high-intensity conflict, it is necessary to consider how such a force can be generated given the units assigned to the brigade by the British Army, and the impact on other operations. 1 Aviation Brigade (1AVNX) currently comprises:

- 1 Regiment Army Air Corps (Recce).
- 3 Regiment Army Air Corps (Attack).
- 4 Regiment Army Air Corps (Attack).
- 653 Squadron Army Air Corps (Conversion Training Unit).
- 5 Regiment Army Air Corps (Northern Ireland).
- 6 Regiment Army Air Corps (Ground Crew Reserve).
- 7 Battalion Royal Mechanical and Electrical Engineers.[93]

In forming the CAB for high-intensity warfighting, 1AVNX would currently restructure to generate attack-reconnaissance battlegroups, so that it would comprise:

- Combat Aviation Brigade Headquarters.
- Aviation Battlegroup 1 (AH64E and Wildcat).
- Aviation Battlegroup 2 (AH64E and Wildcat).
- Aviation Support Group 1 (CH47 from JHC).
- Aviation Support Group 2 (CH47 from JHC).
- Brigade CSS Group.

There are some problems, however, in 1AVNX being able to generate the CAB. The first is that 7 Battalion REME is trained and equipped to support Apache, but not Wildcat. A second gap is in logistics. To be an independent manoeuvre force, the CAB would require an organic logistics battalion in order to move supplies from the divisional support area to the brigade support area. This unit would also be responsible for ensuring the rapid shipment of materiel from the UK to the units deployed. Without this capability, the CAB would be dependent on non-organic units to provide its logistics. While they may have the capacity to do this, they would have other demands that would shape their operational tempo in ways that might delay and disrupt CAB operations. Thus, there is a need to attach a Royal Logistics Corps Battalion to 1AVNX if it is to function as an independent manoeuvre brigade. There is also a need for more fuel bowsers which are currently in short supply and represent a risk for the brigade since their destruction could cripple its operations.

There is a question as to whom exactly will be responsible for establishing the brigade support area and providing force protection to the site. The force protection engineering function need not be an organic element of the CAB, but it must be clearly marked as someone's responsibility.

93. British Army, 'In Front' (No. 5, Summer 2020), <https://www.army.mod.uk/media/10192/adr009405_in_front_5.pdf>, accessed 28 March 2021.

One outstanding question that must be resolved is whether and under what conditions the CAB sits with the division or corps echelon, and whose troops are therefore responsible, or whether wider functions may in certain circumstances need to augment the brigade. Force protection, including personnel to defend the site, and air defence, could be made organic to the brigade, though it is more likely to be drawn from the divisional or corps echelon, since the CAB would sit within the corps support area. Nevertheless, this is similarly a critical responsibility in generating this force that must be assigned to someone and feature in their operational planning. It becomes even more important if 1AVNX is deployed before higher echelons enter theatre.

A more persistent challenge is how this force is to be generated and held at readiness while contributing to support UK operations below the threshold of high-intensity armed conflict. The Ministry of Defence's Integrated Operating Concept describes how UK forces work to protect the homeland, engage with partners and allies to enable them to tackle threats at source, deploy to constrain adversaries by deterrence and denial, and conduct warfighting if deterrence fails.[94] The direction of travel in UK defence planning is to aim to deploy early. 1AVNX can certainly generate units of action to support operations. However, the brigade is likely to avoid reverting to a support model by offering the deployment of its battlegroups in their entirety at staggered readiness. This offers the UK a highly deployable force in competition. However, if a battlegroup is deployed to support an operation, it would then have to be withdrawn, refitted and redeployed to support a major escalation in Europe. In some respects, this is the most manageable scenario. One of the most challenging is whether to deploy elements of 1AVNX early to constrain Russia were tensions to rise in Eastern Europe, or to hold it back. If deployed early – prior to the defensive positions and force protection being prepared to secure the divisional support area – then the force could be suddenly attrited if the situation escalated. The advance force would therefore be unavailable to join the CAB, having already been destroyed. However, if the adversary is seeking to change the facts on the ground before NATO can react, then 1AVNX would likely be forced forward so that the UK's response arrived at the speed of relevance.

Not all missions are equally affected. One that is particularly vulnerable is AH-64 support to the Commando Force. The challenge is that unlike the Royal Navy's Merlin and Wildcat helicopters, AH-64E is not wet-built and must therefore go into deep maintenance upon rotation off ship.[95] Under JHC, with the need to generate units of action, this could be managed. It would, however, present a greater risk to the readiness of battlegroups.

At the same time, the CAB provides policymakers with options that were previously unavailable. For example, the CAB – or a battlegroup from it – could be deployed as the UK contribution to a mission, since as a manoeuvre element it is designed to be able to operate as an independent force package. Had the Iraqi government approved, for example, the UK could have deployed

94. MoD, 'Introducing the Integrated Operating Concept', 30 September 2020, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/922969/20200930_-_Introducing_the_Integrated_Operating_Concept.pdf>, accessed 13 October 2020.

95. Authors' interviews with 1AVNX Staff, Middle Wallop, June 2020.

the CAB to the Kurdish region of Iraq, providing a safe hub from which it could have inflicted widespread attrition of Islamic State forces across the front from 2014 onwards. Thus, 1AVNX offers a highly deployable capability, but if used in this way it would not be concurrently available for deterrence in Eastern Europe.

The problems of concurrency and readiness are not new – defence planners wrestled with them throughout the Cold War. The important point is that in massing aviation as a distinct formation, rather than pulling units of action to support other missions, the calculus has shifted from whether there are available airframes to support a mission, to whether the force is ready and in position to carry out missions of its own. The present tendency to triple and quadruple hat aviation assets will likely have to end, in favour of a clear list of priorities. Perhaps most significantly, if committed to the UK's contribution to NATO operations, the CAB will likely have to service an increasing number of exercises.

Implications for UK Forces

The decision to employ aviation as a brigade not only changes the posture and mission set of aviation forces, but has wider implications for the British Army. The UK will have resurrected a powerful deep strike capability. This would be unique to the UK in NATO, besides the US, and would make UK higher echelons closer in capability to their US counterparts. It could also provide a framework into which the Netherlands could interoperate. However, that capability will have very different availability and tempo to MLRS or long-range precision fires. These differences will mean that the CAB will need to be integrated into training for 3 UK Division and the Allied Rapid Reaction Corps. This training will need to include the requisite allocation of logistics, engineering and force protection. As a practical matter, a logistics battalion will need to be assigned to 1AVNX to make the CAB viable. Other manoeuvre elements will also need to be prepared to host and defend the CAB's FARPs, which would move with the brigade support groups of ground manoeuvre elements.

The CAB will need the Army's Wildcat fleet to receive Seaspray radar and Link 16. These are not technically difficult to integrate or excessively expensive. The force may also require an increase in deployable support kits for Wildcat. Irrespective of whether the force is employed as part of the CAB or in support of other elements, a critical area of concern is munitions stockpiles. These have become deplorably low. Here, government also faces a future capability challenge. The Hellfire is being replaced in US service by the Joint Air-to-Ground Missile (JAGM).[96] The UK, meanwhile, has invested heavily in its complex weapons programme,[97] which has led to

96. US Army, 'Joint Air-to-Ground Missile (JAGM)', <https://asc.army.mil/web/portfolio-item/ms-jagm/>, accessed 15 February 2021.

97. MoD, 'The Defence Equipment Plan 2018: Financial Summary', 5 November 2018, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/753785/20181102-MOD_EquipmentPlan2018_FINAL-v1.pdf>, accessed 15 February 2021.

Brimstone being adapted for aviation use.[98] The UK faces a challenge here in that justifying a significant spend on stockpiles would produce a better return on investment if delivered through a British company, which would favour Brimstone. It would also help to ensure a common munition across air and land forces, with appropriate settings for low collateral damage strikes with restricted rules of engagement below the threshold of direct armed conflict. JAGM offers advantages in being a common munition with the US Army, potentially enabling access to US stockpiles and logistics support in a large-scale conflict. However, without an appropriate initial stockpile of either munition or Hellfire, the aviation force is not credible. One of the easiest ways to alleviate the present critical ATGM shortage for the Apache fleet would be to relax missile carriage hours restrictions, which currently force 1AVNX to decommission Hellfire rounds after far fewer hours of flying time than any other NATO member.[99]

There are several trends for future capability that are of variable use. The British Army is unlikely to deploy at scale in the Pacific theatre. The range increase offered by tilt rotor aircraft is therefore of limited use in a European context because existing flight ranges are relevant to the divisional and corps boundaries within which the CAB functions. Additional speed increases operational tempo across the area of operations by around 10 minutes. Because of this, there is no conceivable reason for the UK to enter the US Future Long-Range Assault Aircraft (FLRAA) programme.[100] There would, however, be value in collaboration with the Future Attack Reconnaissance Aircraft (FARA) programme,[101] since it is likely to deliver a highly capable successor to the AH-64 or a purpose-built penetrating reconnaissance helicopter covering the roles of Apache and Wildcat. The UK is in a favourable position to engage with the programme, because although the US Army Air Corps has concluded following extensive analysis that UAVs are not suitable as reconnaissance aviation platforms,[102] they have also pushed their own crewed reconnaissance helicopter out of service. The Wildcat and Apache attack-reconnaissance team could therefore form an interesting proof of concept for employment, and a basis for experimental cooperation in support of FARA's development. The US and the UK have signed agreements that could facilitate this collaboration.[103]

The issue of uncrewed systems has not featured heavily in this paper. This is because uncrewed platforms, while highly suitable for persistent surveillance, are not yet optimised for reconnaissance. Surveillance means the observation of identified targets. Reconnaissance

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98. MBDA Missile Systems, 'Brimstone', <https://www.mbda-systems.com/product/brimstone/>, accessed 15 February 2021; authors' briefing with MBDA, London, October 2020; authors' interview, JHC, Andover, March 2021.
99. Authors' discussions with Apache crews, JHC Flying Station Wattisham, 27 July 2020.
100. Congressional Research Service, 'Army Future Vertical Lift (FVL) Programme', updated 29 April 2020, <https://fas.org/sgp/crs/weapons/IF11367.pdf>, accessed 15 February 2021.
101. *Ibid.*
102. Authors' interview with JHC staff, Middle Wallop, June 2019; staff report from the US Army Air Service, December 2011.
103. Gareth Jennings, 'UK Includes Future Vertical Lift in Modernisation Agreement With US', *Janes*, 15 July 2020.

requires the finding and understanding of targets. The future operating environment is unlikely to make aircraft requiring persistent command links a viable means of penetrating hostile airspace for either function. This means that uncrewed systems would have to be semi-autonomous. While autonomous systems are highly effective in pattern recognition, reconnaissance – and especially the understand function – often requires noticing elements that do not fit the pattern. This is something that autonomous systems find much harder, since there are technically an almost infinite number of things that do not fit the pattern of interest, but only a particular and yet diverse set of things that amount to relevant breaches of a pattern. Autonomous systems would therefore struggle to spot things such as formation boundaries, which are relatively obvious to human operators. However, there are areas where autonomous or uncrewed platforms could add considerably to the balance of capabilities within a combined crewed and uncrewed family of systems. As mentioned, attritable 'look-and-see' UAVs could enable aviation to positively identify their targets without exposing their positions. Loitering munitions also have sufficient range and time above target to economically increase the number of munitions that could be brought onto a target by a smaller package of helicopters. Thus, rather than seeing uncrewed aircraft as a replacement to crewed systems, the British Army should use the datalinks built into its aviation fleet to provide a hub for experimentation and testing of the former systems. In time, they may be able to take over more functions, but in development the greatest value is likely to be in leveraging the combined advantages from advanced teaming.

The grouping of aviation into a manoeuvre brigade must drive some capability requirements among other units. First, as the force is less likely to be able to generate support to the Future Commando Force for littoral strike, it would place a greater demand on the Royal Navy's Wildcat performing a strike function with Martlet munitions. Second, and more significantly, although UK forces cannot depend on aviation support at present to protect them from armour – since the enemy would select the time and conditions for such an engagement – they are nevertheless heavily dependent. Manoeuvre elements will need to increase their anti-tank capabilities.[104] This is arguably already needed, and simply clarifies an existing requirement.

The grouping of attack aviation assets into potentially decisive mobile anti-tank elements will also significantly increase the threat profile of attack aviation in the eyes of Russian planners in a NATO–Russia conflict scenario. Therefore, the brigade would need to work closely with the RAF and NATO air planners to ensure that aviation activities are planned around the best possible intelligence picture of Russian IADS and red air dispositions, and coordinated with friendly SEAD, DCA and OCA activities where necessary.

The final implication of the CAB is the need for it to benefit from the protection offered by divisional- and corps-level air and missile defence, whether this is provided by the UK or the Allies. The centralisation of the CAB's CSS makes it a key target for enemy long-range precision fires, including Iskandr short-range ballistic missiles.[105] Below this, one of the key threats to

104. Jack Watling, 'Where's the Anti-Tank Reserve?', *RUSI Defence Systems*, 7 July 2020.

105. Missile Threat, 'SS-26 Iskander', <https://missilethreat.csis.org/missile/ss-26-2/>, accessed 16 February 2021.

aviation is red air with look-down capabilities and, to that end, the provision of air defence to enable the aviation to group, refuel and strike from protected nodes is critical to operations. The British Army's Sky Sabre provides a starting point for brigade air defence.[106] However, it does not offer a BMD capability. At present, this is a capability gap only realistically delivered by Patriot PAC-3.[107] Given the lack of budget for such a capability, this is likely to be a dependency on NATO Allies if the CAB is supporting an Article 5 response. It becomes more problematic against adversaries such as Iran, where there is less likely to be a comparable commitment of high-end allied assets, or political cohesion, and the UK would struggle to mount a defence against Iranian ballistic missile strikes. This is not a problem isolated to aviation, but the CAB concept underscores a vulnerability that is currently all too apparent across the force.

106. Global Defence Technology, 'Sky Sabre: Inside the UK's Missile Defence System', <https://defence.nridigital.com/global_defence_technology_apr18/sky_sabre_inside_the_uks_missile_defence_system>, accessed 16 February 2021.

107. Lockheed Martin, 'PAC-3', <https://www.lockheedmartin.com/en-us/products/pac3-mse.html>, accessed 16 February 2021.

Conclusion

WITH THE FORMATION of 1 Aviation Brigade, the British Army has made aviation critical to its warfighting capabilities, as well as to those of the joint force. The change in the threat environment produced by modernised adversary equipment and a return to great power competition makes a compelling argument for ensuring that aviation operations are executed with sufficient senior expert representation in joint planning and with dedicated command and control. This applies in most operating environments, but is especially relevant in operating to deter peer adversaries and in great power conflict.

The scale of hostile armoured forces in any encounter with the Russian armed forces in a NATO Article 5 context would require a large concentration of ATGMs to be brought to bear rapidly to halt or break up the assembly of formations that would otherwise be able to punch through UK or allied ground forces. Given the paucity of anti-tank firepower among the rapidly deployable land units of the Army, and the agile and responsive nature of aviation, the use of attack-reconnaissance aviation battlegroups in this role offers one of the easiest routes to fielding potentially decisive anti-tank firepower. Simply allocating packets of Apaches to give anti-tank support to ground manoeuvre elements would not provide sufficient firepower alone to halt Russian motor-rifle or tank manoeuvre elements. Furthermore, it would force the Apaches to engage enemy formations on the axis of their advance, potentially in daylight and with a high likelihood of encountering Russian SAMs, AAA and possibly fixed- and rotary-wing assets supporting the enemy formation.

Second, the peer or near-peer environment is characterised by the presence of systems that pose serious risks to aviation at significant ranges, including ground-based defences, over-the-horizon early warning sensors and fixed-wing look-down/shoot-down threats. These threats will continue to get more sophisticated as they are major areas of focus for competitor states, which recognise the threat posed by NATO air and aviation capabilities. Such threats do not preclude the successful use of aviation in combat roles, but they do increase the risk level substantially compared to that encountered in previous conflicts. As such, the need for dedicated command and control to plan and execute aviation operations incorporating the latest intelligence on enemy force dispositions and activities from across the joint force will be essential to allowing aviation to operate sustainably in such scenarios. The grouping of aviation as a self-contained manoeuvre element with its own planning and support structures should improve the ability to conduct this detailed mission planning and coordination with the rest of the joint force. The concentration of attack-reconnaissance aviation forces for dedicated manoeuvres at scale will inherently increase the signature of those operations and make them a higher-priority target for enemy actions. However, an organic brigade-level combat aviation headquarters, subordinated to the divisional or corps echelon, would also allow much closer coordination with other joint activities such as SEAD, EW, OCA/DCA and long-range fires to create and exploit opportunities for concentrated aviation assets to conduct decisive strikes on hostile formations and logistics in the deep battle area.

Third, the grouping of Apaches specifically within an independent manoeuvre formation should act as a forcing function for the rest of the Army to confront the degree to which a limited fleet of AH-64s has been double and triple counted in recent years to theoretically buy out serious deficiencies in anti-tank capabilities among ground forces. While potentially politically uncomfortable, anything that leads to an increase in ground forces' organic lethality would greatly improve the British Army's overall credibility as a warfighting entity within NATO and elsewhere. It also represents a challenge for the Commando Force and places greater demands on the capacity of the Wildcat HMA 2 force to provide anti-tank capabilities and fire support with the FASGW(L) missile system in lieu of presumed shipborne AH-64E detachments.

Fourth, independent aviation battlegroups could be deployed as a standalone alliance or coalition contribution in lower-threat conflicts. Many of the partner forces which UK and other Western forces have recently sought to fight by, with and through have been able to field plenty of light infantry with a good knowledge of local terrain and a great deal of combat experience. Some have even fielded significant medium armour and indirect fire support capabilities. What none can field is a force with the agility, responsiveness and ability to concentrate anti-tank and anti-infantry firepower where required. Massed attack-reconnaissance aviation can offer this. It is also a capability that is unmatched outside of the US within NATO, allowing such a force to offer the UK a relatively unique asset to contribute to the Alliance.

Finally, giving 1AVNX the status of a manoeuvre brigade implies a need to supply it with a robust organic logistics and support architecture to reduce its dependence on the divisional support group for movement of key spares and consumables in a conflict zone. If this were done, it would improve the resilience and likely availability and sortie rates which the force could generate when deployed – especially if deployed as part of a divisional or corps-scale force whose logistics scale and focus were not conducive to meeting the specific needs of aviation.

In order to enable this concept of operations, several key equipment dependencies have been identified. The first is for adequate supplies of munitions to be able to credibly generate decisive warfighting effects, which includes compatibility with JAGM to enable drawing on US stocks even if the UK chooses Brimstone to replace Hellfire. The second is to equip the Wildcat AH1s with the Seaspray radar to enable them to fulfil the critical organic ISTAR requirements of the brigade, and Link 16 to enable them to better share their situational awareness picture with AH-64E and other joint assets. The third dependency is an awareness within the brigade and the wider divisional command structure that the aviation manoeuvre element is a potentially lethal but distinctly fragile force if discovered and fixed in a meeting engagement by enemy forces. As such, it should not be employed within the whole force in a way likely to fix it in situations where it has to be committed under clearly unfavourable circumstances in terms of hostile dispositions. If enabled to operate sustainably over multiple operational cycles, the cumulative lethal and shaping effects on enemy manoeuvre forces could be decisive. However, if forced to operate against the strongest part of an enemy advance without adequate planning and enablers, or in daylight without cover from terrain, it would rapidly succumb to attrition. Finally, it is evident that a wider range of tasks will be carried out by uncrewed systems over time. These, as yet, do not offer a replacement to crewed aviation. However, if invested in, they could offer a powerful augmentation to the brigade's capabilities and enable the integration of a wider array of joint effects into aviation operations. This should be a critical path of spiral development to maximise the possibilities opened by AH-64E.

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Appendix: UK Aviation Fleets

THE BRITISH ARMED Forces operate a range of rotary wing (aviation) types to cover a variety of missions in support of land and maritime operations.

Table 1: Frontline UK Rotary Wing Inventory

Type	Total Inventory	Primary Roles
Wildcat	62	Reconnaissance, light attack, light lift, fire support control.
Puma	23	Medium lift.
Chinook	60	Heavy lift.
Apache	50	Attack, reconnaissance.
Merlin	55	Medium lift, anti-submarine warfare, maritime airborne early warning.

Source: Ministry of Defence, 'UK Armed Forces Equipment and Formations 2019', August 2019. All the Puma and nine Chinooks will be retired during the early 2020s.

The Chinook and Puma fleets are operated by the RAF in support of both land and maritime operations, the Merlin fleet and 28 Wildcat HMA2 variants by the Royal Navy, and the remaining 34 Wildcat AH1 and Apache fleet by the British Army.

Ch47 Chinook

The twin main rotor configuration of the Chinook gives it surprising agility for its size as well as additional resilience under fire and lifting capacity compared to other helicopter designs in its weight class. It has seen service in every conflict that the UK has been a part of since the Falklands War. The Chinook is currently in service in three variants with the RAF. The HC Mk.4 is an upgraded derivative of the older Mk.2 standard, the HC Mk.6 is a UK variant of the newer US CH-47F model Chinook, and the HC Mk.5 is a special forces support upgrade of the Mk.3 with larger extended-range fuel tanks and upgraded defensive and communications systems fitted.[108] The Mk.4 fleet is currently being upgraded to Mk.6A standard with new digital avionics. The US has also approved a potential sale of MH-47G aircraft for UK special forces support operations, which would offer airframe and system commonality with US Special Operations Command.[109] This sale is part of the Chinook capability sustainment programme and will ultimately replace nine older airframes which are to be withdrawn from UK service

108. Authors' discussions with 7 Squadron personnel, RAF Odiham, 27 November 2017.
109. Defense Security Cooperation Agency, 'UNITED KINGDOM – H-47 CHINOOK (EXTENDED RANGE) HELICOPTERS AND ACCESSORIES', 19 October 2018, <https://www.dsca.mil/press-media/major-

as part of the 2021 Defence Command Paper plan.[110] All UK Chinook variants carry two 7.62mm-calibre M134 Miniguns in side windows for self-defence, with the option to mount an additional 7.62mm M60 machine gun on the tail ramp if required. They can also be equipped with modern missile-approach warning systems and countermeasures. Chinooks can carry up to 55 troops or around 10 tonnes of internal and underslung cargo, making them the British Armed Forces's most capable vertical lift asset.

Puma

The Puma HC2 is a smaller medium-lift helicopter with a conventional main rotor and tail rotor arrangement. The Puma can transport up to 12 troops with full combat gear or 16 passengers, or up to two tonnes of internal and underslung cargo. The advantages of the Puma compared to the Chinook include lower cost, smaller footprint which allows landing in more confined areas, and the ability to be air-deployed by C-17 or other fixed-wing heavy-lift platforms and quickly returned to flying condition once delivered.[111] However, it is also slower, with marginally less range and greater performance degradation in hot and high environments than Chinook. It is to be retired from service as a result of the 2021 Integrated Review and replaced with an as yet unspecified medium-lift helicopter.[112]

AH-64 Apache

The AH-64D Apache Longbow is the British Army's attack helicopter, with 50 remaining in service. All 50 will be replaced by 2024 by AH-64E Apache Guardian variants purchased via Foreign Military Sales from Boeing.[113] The first AH-64Es have been delivered to the British Army and initial operating capability for the new variant is set for 2022. The AH-64D/E is designed around a weapons fit of AGM-114 Hellfire radar or laser-guided anti-tank missiles, 2.75-inch rocket pods and a chin-mounted 30mm cannon, cued by the Longbow radar mounted above the main rotor head and an EO/IR sensor ball mounted on the nose. The Longbow radar operates in a relatively high frequency band of the radar spectrum, giving excellent target acquisition, classification and rapid detection capabilities, but limiting its effective range.[114] This was a specific design choice, optimising performance against targets within range of the primary Hellfire weapons system.

It is optimised for rapid destruction of enemy armoured formations using very-low-altitude, NOE flight patterns to appear from cover, use the Longbow radar to rapidly acquire, classify and then fire salvos of Hellfire missiles before returning to cover. However, the Apache has also

arms-sales/united-kingdom-h-47-chinook-extended-range-helicopters-and-accessories>, accessed 13 August 2020.

110. MoD, *Defence in a Competitive Age*, CP 411 (London: Her Majesty's Stationery Office, March 2021), p. 54.
111. RAF, 'Puma HC2', <https://www.raf.mod.uk/aircraft/puma-hc2/>, accessed 30 March 2021.
112. MoD, *Defence in a Competitive Age*.
113. Gareth Jennings, 'UK Now Has All 50 AH-64E Apaches Under Contract', *Janes*, 10 March 2020.
114. Authors' discussions with Apache crews, JHC Flying Station Wattisham, 27 July 2020.

proven highly effective at providing close support to friendly troops in contact in both Iraq and Afghanistan, as well as formation attacks behind enemy frontlines against facilities and lines of communications in Iraq and Libya.[115] The Apache is designed with multiple levels of mechanical redundancy across all key systems to ensure that hits from enemy ground fire are unlikely to completely disable the aircraft, and the fuel tanks, main rotor assemblies and crew are protected by armour sufficient to withstand .50-calibre hits.[116] It is also equipped with advanced electronic support measures (ESM) capabilities to warn the crew of hostile radar emissions, and a modern MAWS and countermeasures suite.

The AH-64E variant will improve the radar range, the capacity of the ESM suite and add the option for upgrading the radar to an active electronically scanned array (AESA) type in the future, as well as adding Link 16 datalink capabilities. The AH-64E will also bring a full-colour moving map display, as well as the facility for controlling and integrating the feeds from UAVs into the cockpit to improve situational awareness. The target acquisition and designation sights and FLIR capabilities will also be upgraded in the AH-64E.

AW 159 Wildcat

The AW 159 Wildcat is a light transport, lift, battlefield and maritime reconnaissance helicopter produced in two separate variants for the British armed forces. The HMA2 is the maritime version which operates from Royal Navy ships in the light attack, reconnaissance and anti-shipping roles. The HMA2 is equipped with a Seaspray 7400E AESA radar under its chin and a nose-mounted EO/IR MX-15 sensor ball. The radar allows rapid detection and simultaneous tracking of up to 100 moving entities including individuals, vehicles or objects over water or land while remaining difficult to detect for enemy ESM assets.[117] As an AESA with software-defined frequency, wavelength and pulse repetition capabilities, the Seaspray can be optimised to allow standoff ranges well in excess of 100 km if required.[118] The Wildcat HMA2 can also be fitted with stub wings capable of carrying up to 20 future FASGW(L) missiles, also known as Martlet, or up to four FASGW(H) Sea Venom anti-ship missiles.

The Army version is the Wildcat AH1. It is not currently fitted with the Seaspray radar or stub wing weapon options, relying entirely on the MX-15 sensor ball for its primary reconnaissance and fire-support control mission. The AH1 variant also equips the Commando Helicopter Force's 847 Naval Air Squadron for light transport and reconnaissance duties in support of littoral operations. The Wildcat can carry up to 6,200 kg of stores, passengers, weapons or cargo. Both versions of Wildcat also carry an M3M .50-calibre heavy machine gun for self-defence, target marking and light offensive supporting fire.

115. *Ibid.*
116. *Ibid.*
117. Authors' briefings at Leonardo Helicopters, 6 August 2020 and RNAS Yeovilton, 7 August 2020.
118. *Ibid.*

Additional Airframes

The Army also operates five Bell 212s in Brunei for search and rescue and light transport duties, as well as a single unit of Gazelle AH.1 light reconnaissance and counter-IED helicopters in Northern Ireland and at the BATUS training area in Canada.[119] Both types are expected to be replaced during the mid-2020s by the medium-lift helicopter acquired to replace Puma.

119. MoD, 'UK Armed Forces Equipment and Formations 2019', August 2019. See also Niall Grant, 'British Gazelle's to Continue in Service Until 2025', *Flying in Ireland*, 3 August 2016, <https://flyinginireland.com/2016/08/british-gazelles-to-continue-in-service-until-2025/>, accessed 14 August 2020.