

LEVERAGING UK CARRIER CAPABILITY

A Study into the Preparation for and Use of the *Queen Elizabeth*-Class Carriers

Tobias Ellwood MP



Royal United Services Institute

OCCASIONAL PAPER

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This Occasional Paper is based upon evidence collated from a six-month study of Britain's future carrier capability. It brings together ideas and concerns expressed by a wide variety of personalities from the defence industry, and military and diplomatic communities, many of which were provided off the record.

The views expressed, conclusions drawn and recommendations made in this paper are the author's own, and do not reflect those of the Ministry of Defence, British government or RUSI.

Acronyms and Abbreviations

DCDC	Development, Concepts and Doctrine Centre
DfID	Department for International Development
EU	European Union
ISR	Intelligence, Surveillance and Reconnaissance
ISTAR	Intelligence, Surveillance, Target Acquisition and Reconnaissance
JSF	Joint Strike Fighter
LPH	Landing Platform Helicopter
MoD	Ministry of Defence
NATO	North Atlantic Treaty Organization
NSS	National Security Strategy
SDR	Strategic Defence Review (1998)
SDSR	Strategic Defence and Security Review
STOVL	Short Take-Off and Vertical Landing
UAS	Unmanned Aerial Systems
UN	United Nations
VTOL	Vertical Take-Off and Landing

Forewords

Lord Robertson of Port Ellen

Here is the case which presently dares not speak; the case for using both of the expensively procured aircraft carriers being built for Britain's portfolio of military assets. It is an eloquent, tightly argued and very convincing case for adding both carriers to the Royal Navy's fleet. It should be noticed and addressed.

In the Strategic Defence Review of 1998, two large aircraft carriers were the headline new capability. They were to replace Britain's three sub-scale but highly useful *Invincible*-class carriers and were at the heart of the restructured armed forces. As I said in my introduction to that review, 'In the post Cold War world, we must be prepared to go to the crisis, rather than have the crisis come to us. So we plan to buy two new larger aircraft carriers to project power more flexibly around the world.'

That review's conclusion of having flexible, sustainable, hard-hitting forces with the equipment to make them effective was universally accepted at the time, and is still the basis of the latest Strategic Defence and Security Review. The decision to mothball one of the new *Queen Elizabeth*-class carriers was clearly driven by cost and not defence reasons and was widely seen as undermining the basis of this crucial and expensively bought capability.

As a former secretary of state, I am wary of promoting the case for one capability over others without balancing all of the elements. That is why in the defence review I led we looked at all capabilities in the round and came to considered and balanced conclusions which, unlike any previous review, had the support of all of the service chiefs both in public and in private. Central to that important consensus was the decision on having two aircraft carriers, and it should be discarded only on the strongest and most persuasive grounds.

Tobias Ellwood has not fallen into the trap of arguing the case for commissioning and operationalising the second carrier in isolation. He has made his case on its role in future overall strategy and that is why I commend his thinking for the deepest and most careful consideration.

Rt Hon the Lord Robertson of Port Ellen KT GCMG HonFRSE PC
Secretary of State for Defence 1997–99
Secretary General of NATO 1999–2003

Michael Codner

The two *Queen Elizabeth*-class aircraft carriers that are at present being built were widely portrayed as white elephants in the public debate such as it was before the 2010 Strategic Defence and Security Review (SDSR), and also in the immediate aftermath of the decision to complete the building of both but to put the second, HMS *Prince of Wales*, into extended readiness.

Perceptions of the strategic context at the time of the SDSR fed on recent history of the Iraq war and subsequent occupation and the conflict in Afghanistan. The defence review was avowedly short-termist because of this ongoing war, postponing several key decisions to follow further studies. In particular, the brutal cut in army numbers was held off. A decision about the possible sale of the *Prince of Wales* was postponed until after the next, now-cyclical, defence review to come in 2015; and crucial choices about the replacement of Trident nuclear-missile submarines are delayed until after the next general election. The dominant focus in British military culture in 2010 was on counter-insurgency and the conclusions of the 1998 Strategic Defence Review (SDR), typically vilified with the mantra ‘quick in – quick out’, were considered outdated and anyhow unrealistic.

Things have changed hugely following the decision to withdraw from Afghanistan in 2014 and as the Ministry of Defence and armed forces begin to prepare for the next review. We are to expect a strategic shift from ‘campaigns’ to ‘contingency’. There is a strong hint of déjà vu here: is this not precisely what the 1998 SDR and ‘quick in – quick out’ was all about? It is easy to be disparaging about this crucial debate, which was sadly dodged in the 2010 SDSR, about the ‘British way of war’, which goes back in history at least to Jonathan Swift’s provocative essay of 1713, *On the Conduct of the Allies*, in which he says about a major ground campaign that ‘against all manner of prudence or common reason, we [England] engaged in this war as principals, when we ought to have acted only as auxiliaries’, with the vast associated costs. Elsewhere, Swift advises making the most of England’s maritime power as an island nation.

Tobias Ellwood is a strong protagonist for the two aircraft carriers as the core of Britain’s naval capabilities for major combat operations – carrier strike and littoral manoeuvre – but importantly for a range of other roles and tasks across the spectrum of conflict including humanitarian assistance and diplomatic engagement. This survey is particularly useful because there is often a presumption that a carrier is merely a platform for fixed-wing combat aircraft. It is in fact a sea base for a vast range of military, constabulary and benign contingencies. Ellwood also discusses capability options comprehensively, looking to agility, adaptability and coherence.

Most importantly, Ellwood explains the roles of the carrier in contributing to defence policy and national military strategy. This is precisely the discussion that is well overdue and timely with the next defence review in mind. The heart of the debate is not about ‘cats and traps’ or the type of F-35 aircraft that will be flown from the carrier in the strike role. It is about the carrier’s purpose and value in contributing to a particular strategic choice. And here’s the nub. This paper presumes that the ‘shift to contingency’ implies a predominantly maritime strategic choice for the United Kingdom. There are strong arguments for this choice. As navalists continually remind us, Britain is an island nation with great economic dependence on access to the sea. Territorial obligations abroad are to a global, albeit small, archipelago of Overseas Territories. Major interventions will be multinational, and the obvious ‘appropriate’ British contribution should be predominantly maritime. Europe needs to come up to the mark in military capability to secure the strategic bargain of its member states with the US; two large carriers speak volumes for Britain in this respect.

The counter-argument is that the reason Britain retains its aspirations to be an expeditionary military power and pays more proportionally for defence than most European allies is for global influence as a route to a more secure security environment for the nation. While naval forces are useful tools of influence for prevention and early on in a crisis, land forces show the commitment that is essential for influence. And British forces have a deserved reputation for experience and competence in this respect. There is the problem of embroilment on the ground and political reluctance to commit to long-term interventions, but this is also true of all Western nations with expeditionary capabilities and intentions. Useful military coalitions will still need ground troops and heavy armour from somewhere.

This matter of global influence reveals another more fundamental strategic choice for the UK. Is an expeditionary defence budget of 2 per cent of GDP really affordable in the longer term, and is Britain really any safer as a result? Would a more modest budget and set of military capabilities focused specifically on direct needs, obligations and responsibilities be more acceptable to the British electorate in the future? Will a government be able to measure the nation’s global influence to convince the British people? The ‘plus influence’ and ‘minus influence’ arguments both challenge the need for a two-carrier navy as a priority for government spending.

These debates – captured crudely in this preface – must be had now in good time for the next defence review.

Michael Codner

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Introduction

Political parties (and successive governments) have been united in supporting the concept of aircraft carriers as part of Britain's defence mix, but have differed on the detail. With two *Queen Elizabeth*-class carriers now under construction, the question the present government faces is whether to operate two carriers or one and what balance of carrier-strike and expeditionary assets should be included.

Look beyond the concept, and political agreement about the details is hard to find. Almost from its inception, the debate about the successor variant of the *Invincible*-class carrier has been confused, even undignified. Mention the subject in Parliament and one is immediately drawn into the weeds about the type, performance and cost of the aircraft that will finally replace the iconic Harrier. Whilst the *Queen Elizabeth* class is optimised to deliver carrier strike, it can also operate as a Landing Platform Helicopter (LPH) ship operating in a variety of roles, from littoral manoeuvre to crisis response and humanitarian tasks. In an age of reduced defence budgets this new size of ship, accompanied by the right assets, could set an international standard in how a versatile aircraft carrier of the future should operate.

This, however, will not happen if politicians and service chiefs fail to recognise that this is a fast-changing world. The UK's allies and enemies, technology and the conduct of warfare will look very different when the carriers become operational in 2020. This Occasional Paper attempts to illustrate how conventional institutional thinking is hindering the development of the ways in which the *Queen Elizabeth* class should be deployed. Before contemplating the aircraft mix that the carrier will require, this paper first considers Britain's strategic objectives; the environments in which the UK's security forces are likely to find themselves operating over the next forty years; and the roles a carrier task force might play.

Of course, it is impossible to predict the future, but it is possible to ensure that the hardware, software and human resources incorporated into these ships have the built-in agility to adapt to evolving techniques, technology and likely tasks. Chapter I assesses Britain's status, influence and vulnerability over the next few decades; the consequences of globalisation; and Britain's changing relationships and increased interdependence. It also examines emerging threats and the demise of the UK's historical qualitative and quantitative military advantage as the conduct of asymmetric warfare matures. The emergence of state-on-state conflicts should not be discounted.¹

Returning to the F-35B (short take-off and vertical landing – STOVL) variant as the preferred choice of Joint Strike Fighter (JSF) for the *Queen Elizabeth* class will save money and ensure an earlier operational start date. However,

issues such as the impact on the carrier deck's functionality, which service 'owns' the aircraft, and the mix of assets used in the littoral-manoeuve role do require some examination. Two studies have clearly stated that the maritime expertise lies with the service that operates in the maritime domain: the navy.² Chapter II considers these issues and argues that they must be answered well before the next SDSR, along with the fundamental question of whether there will be one or two carriers in operation.

Whilst Operation *Ellamy* – Britain's involvement in the 2011 NATO campaign in Libya – proved how forward basing and frequent mid-air refuelling increases the combat footprint of our fast jets, there is no doubt Britain's carrier capability was sorely missed during that campaign. Chapter III looks at some of the lessons that can be learned from Libya, how the *Queen Elizabeth* class might be used in the future and how the 'decade without a carrier' charge can be answered. One way to do this is by thinking beyond the conventional carrier-strike and littoral roles that carriers traditionally provide and by delivering more potent payloads with rotary-wing aircraft.

Displacing 65,000 tons, the *Queen Elizabeth*-class carriers cannot be directly compared to the smaller US *Wasp* and *America* classes (at 45,000 tons) or the *Nimitz* and *Ford* classes (at 100,000 tons) used by the US Marines and US Navy, respectively. Consequently, there is little precedent for how these British ships might function and thus there is a rare opportunity to develop a new strategic maritime capability. This opportunity will only be harnessed if convention and prejudice are set aside and future technological possibilities are recognised. Chapter IV argues that despite incredible advances in technology, the current debate over-emphasises the importance of familiar delivery platforms (fast jets), rather than the overall package that the carrier can deliver. There needs to be a greater focus on what capability the platforms can offer, both strategically and operationally. This, in turn, means increased understanding of the procurement of precision-guided munitions.

Finally, Chapter V builds on the lessons learnt in Libya by exploring alternative delivery platforms, in particular unmanned aerial systems (UAS) and rotary capability, that are not presently being considered by the government. If these are adapted, they could be put to use in the immediate future. UAS will play an increasingly central role in future conflict; the focus must therefore be placed upon developing a strategy to exploit this capability from the *Queen Elizabeth*-class carriers.

The US and UK are operating under a Statement of Intent for Enhanced Carrier Cooperation and Maritime Power Projection. Signed by the US Secretary of Defense Leon Panetta and Secretary of State for Defence Philip Hammond on 6 January 2012, this broad-ranging agreement has a top-level aspiration to integrate a Marine Corps squadron of F-35B onto the *Queen Elizabeth*-

class carriers and a UK F-35B squadron onto US L-class carriers. This must include the mutual development and integration of procedures, vital mission systems infrastructure and weapons stowage.

Although there is a clear distinction between carrier-strike and littoral-manoeuve roles, the unique size of the *Queen Elizabeth*-class carriers opens up possibilities to execute multiple missions, albeit noting that there will be compromise in terms of sortie generation, tempo, effective radius of action and weight of effort delivered (in personnel, weapons or time on station). The class has the potential to offer advanced, sea-based (joint) command and control from which forces fielded by the UK, NATO or a coalition could be administered during a major crisis or contingency operation.

The *Queen Elizabeth* STOVL strike carrier has the potential to set the standard of fifth-generation naval aviation and how the UK uses these carriers will be monitored carefully by friend and foe alike. In order to avoid the age-old procurement challenge of designing equipment for the last war, it is imperative to recognise the changing nature of warfare and the technological advances that expedite that change. If these challenges are not factored in soon, the carriers' full potential may be missed.

Libya offered the opportunity to assess the optimum mix of both traditionally land-based attack helicopters (Apache) and assault-support helicopters (Chinook), and maritime-based platforms in the Sea King Mk4 assault helicopter, Sea King air surveillance and control and Merlin Mk1 anti-submarine warfare helicopters. In comparison to HMS *Ocean*, which can operate a maximum of eighteen helicopters, the *Queen Elizabeth* class can operate up to forty aircraft on a flight deck that is more than double the operating area. This capacity provides the UK with a significant future capability expansion.

Following the billions of pounds already spent on its procurement and build, the actual running costs per year for a second carrier (£65 million, excluding manpower and upgrades during refits) compare favourably to that of a British air base (for example, RAF Marham comes to £144 million per annum) and is a relatively small price to pay for the degree of strategic influence and operational capability it offers. Considering the number of engagements (both war-fighting and peacekeeping) that Britain is likely to experience over the lifetime of these carriers, the net increase in capability that a second carrier offers will more than pay for itself.

Summary Arguments for Two Carriers

The strategic message underlining Britain's position as a global player with a military power of the first rank will differ depending on the number of carriers brought into operation, their availability, and how they are equipped,

commanded and able to adapt from war-fighting to conflict-prevention and peacekeeping roles. Two carriers, at an annualised cost of £65 million each, would provide both strategic and operational benefits.

Diplomatic and Military Statement of Intent

Committing to two operational carriers sends a powerful message of intent to potential adversaries (state and non-state) and also to UK allies, particularly the US, allowing Britain in turn to employ greater leverage on American decision-making. It would elevate Britain's ranking as Europe's senior military power, allowing it to speak with more authority and lead the debate in both NATO and the EU on defence and security matters.

Guaranteed Carrier Capability

A second ship would mean that a European carrier group could always be available. A single carrier, by contrast, would only be operational two-thirds of the year. (Note the sole French carrier, the *Charles de Gaulle*, was providing 40 per cent of all allied air sorties during the Libya campaign until it was withdrawn for scheduled maintenance). This could have saved the £100 million forward-basing bill evident in the Libya campaign. Elsewhere, it is worthwhile to note that the US continues to fly 30 per cent of all Afghan missions from carriers in the Indian Ocean.

Greater Flexibility of Carrier Utility

A single-running carrier would result in enormous demand to remain continuously in the carrier-strike rather than the littoral or expeditionary mode. Although the carrier-strike mode gives Britain a strategic and operational advantage over any likely adversary, there will arguably be more demand (and at shorter notice) for the carrier in littoral-manoeuve mode – strategic shocks aside – over the next fifty years.

Most Effective Use of Forty-Eight F-35Bs

The limited availability of a single hull in carrier strike would fail to justify the investment in forty-eight JSF F-35B variants. The ship's crew and the full complement of pilots would struggle to complete the obligatory (day and night) flying required to remain safe and current – both in the strike role and also to fly safely at sea – throughout the year. This challenge is considerably mitigated if two carriers are available.

Re-Rolling Issues

To re-role a carrier from carrier strike to littoral manoeuvre would take weeks, and the reverse even longer; technical licences must be secured to clear the carrier for strike operation, in addition to the significant logistical changes between roles. The entire ship, for example, must pass a three-month period of complex operational sea training to ensure operational readiness and land-based JSF pilots would need up to ten weeks to work up

the required training level. Utilising two carriers allows one to be worked up in either mode for longer, saving money and allowing faster response times to potential new threats.

Tailored Littoral-Manoeuvre and Crisis-Response Capability

The availability of a single carrier alone would prevent the Royal Marines (returning from infantry work in Afghanistan to their primary amphibious role in the maritime environment) from working up leading-edge expeditionary skills using state-of-the-art marinised equipment and transport. Running a single carrier would inhibit the Royal Marines' capability regeneration and further exacerbate the current limitations on embarked training of logistics-support personnel and equipment and a 'borrowed' green-rotor capability, provided at short notice – the latter with highly compressed training timelines and subsequent embarkation for the minimum possible duration.

UAS Use

A single carrier provides limited scope (due to the carrier-strike demands) for more creative operations involving UAS (soon to be the norm) to be developed. By the time the first carrier becomes operational, UAS are expected to occupy the battlespace as much – if not more – than manned vehicles, contributing to ISTAR, strike, real-time data linking, replenishment and special-forces roles.

Increased International Collaboration

A second carrier would provide greater capacity for closer collaboration with NATO allies in both the littoral-manoeuvre and carrier-strike roles. For example, the US Marine Corps does not have its own embarked ISTAR assets, which could be provided by the *Queen Elizabeth*-class carriers using the Crowsnest ISTAR or a future UAS. Italian and US Marine F-35Bs could also mount operations from a British carrier if theirs were not available.

Independent Reliability

Bilateral maritime (carrier) agreements with allies are well intended, but require the absolute alignment of foreign policy and operational availability if carrier capability (with a single carrier) is to be guaranteed. As Operation *Ellamy* illustrated, the US withdrew its carrier prematurely for political reasons and France did the same for operational reasons.

Notes and References

1. Ministry of Defence, 'DCDC Strategic trends programme', <<https://www.gov.uk/government/organisations/ministry-of-defence/series/strategic-trends-programme>>, accessed 27 August 2013.

2. Major General Paul Newton conducted three studies in 2008–09 into the make-up of Joint Force Harrier, concluding that the service which operates aircraft in the maritime domain – the Royal Navy – must continue to do so and that the RAF could not complete this task as a single service. The Edward Ferguson study, undertaken within the MoD in 2012, proposed that operation of the F-35B from the *Queen Elizabeth* class must be in sufficient numbers to provide a viable power-projection capability, thereby maximising the return on investment, and must also be operated by members of the Royal Navy.

I. Britain's Global Interests, 2020–50

The carriers will become operational from 2020 and serve for up to five decades. The UK is therefore obliged to design a capability not to meet its interests and needs of today, but of the future. Of course, there is no crystal ball: but both the government and the Ministry of Defence (MoD) must consider factors such as changing British interests and alliances, expected advances in technology, developments in the conduct of conventional and asymmetric war, growing political and environmental tension points around the globe, and the UK's own recent experiences.

Understanding these factors and others can help to describe what role the *Queen Elizabeth* class might play beyond simply 'providing carrier strike'. Too often hidden agendas and regimented, compartmentalised procurement processes hamper visionary thinking. This has led, for example, to the Typhoon's initial design omitting an air-to-ground attack capability and the British Army's AW159 Wildcat being unable to deploy advance missile systems as per the naval variant.

To date there has been little agreement, in part due to different service conceptual thinking, as to how the most costly defence project ever (carrier and aircraft combined) will be utilised, beyond the decision over which JSF variant (and consequently deck design) to purchase. With a lead time of eight years, appreciating the full contribution the carriers can offer would ensure that they commence operations as state-of-the-art assets with the built-in agility to adapt quickly in the future rather than date before their time.

Changing State Players and Alliances

The next few decades will see the development of a multipolar world in which Britain's interests will branch beyond conventional areas towards Latin America and the Far East. Increased globalisation will see ever-more dependence on international shipping lanes for trade and energy requirements, which will alter as the Arctic ice retreats, opening up new northern routes.

UK and then US supremacy at sea has been the fundamental strategic shaper of the last 200 years. Freedom of the high seas is the underpinning requirement of the modern Western world and of creeping globalisation. It is by no means clear that this supremacy will remain unchallenged during the carriers' lifespan. As a global maritime trading nation, the UK must be able to respond.

The UK will be competing with strengthening influencers such as Russia, Iran, India, Brazil and China – all current or aspiring carrier-operating nations – which will have their own agenda regarding British allies and trading partners.

Whilst direct conflict is unlikely, war by proxy is probable, with the distinction between non-state and state actors continuing to blur.

In this context, the strategic and tactical role of the carrier capability in defending and promoting British interests and influence deserves serious consideration, and demands a clear perspective of where the UK wishes to sit on the world stage. UK carrier capability has the opportunity to act as an instrument of both soft and hard power whilst showcasing the best of British hi-tech, heavy-engineering and industrial innovation.

The UK carrier capability is a clear statement of ‘conventional deterrence’, complementing the UK strategic deterrent as its ultimate security guarantee. As a permanent member of the UN Security Council, the independent ability to deploy a credible and powerful conventional force that enables access to most of the globe by sea is compelling. This force offers Britain the opportunity to commit political support in emerging crises to deter, prevent, coerce or – if necessary – destroy an aggressor, as envisaged in the UK’s National Security Strategy (NSS).

Governments want the maximum number of diplomatic options to be available – to be able to take actions that are easily reversible, to signal intent and to escalate or de-escalate pressure – whilst contending with the least number of constraints and restrictions. Maritime-based carrier strike and intelligence, surveillance and reconnaissance (ISR), together with amphibious forces, are the acme of military capability and, with maximum political utility, are able to project forward rapidly, poise covertly or overtly as the situation requires, and act as necessary without the constraints of access permission from third parties.

The carrier force will allow engagement without unnecessary entanglement, reducing the political challenges generated through a large, deployed land footprint over an extended period, as witnessed in Iraq and Afghanistan. For a prime minister, it can offer a statement of decisive action and greater opportunity for ‘effects without regrets’.

Exploiting Carrier Opportunities with the UK’s Allies

With around two-thirds of the world’s population (4 billion people) living within 250 miles of a coastline, the likelihood of carriers playing a role in the areas mentioned above is significant. For example, a decade after operations began in Afghanistan, the US continues to conduct 30 per cent of its air missions from carriers based in the Indian Ocean, some 450–700 miles from the conflict zone. Through alliances such as NATO, coalitions formed under UN Security Council resolutions and bilateral arrangements, agreements can be forged that, in times of tension or conflict, allow the UK to gain access to and operate from foreign air bases. The capacity of the *Queen Elizabeth*

carriers provides an opportunity to offer a similar, floating, forward basing and operational platform to allies operating STOVL aircraft, helicopters and UAS. Such an offer to potential allies would need to be made soon to allow training programmes, specialist capabilities and specific procurement purchases (such as helicopters with automated rotor-fold capability) to be established by potential partner nations.

This approach must be caveated, on the one hand, by growing domestic political reticence in committing troops to NATO operations (for example, both Germany and Poland opted out of the Libya campaign, and Spain and France exited Afghanistan early) and, on the other hand, the developing capabilities of non-NATO countries (such as Australia with its large but embryonic amphibious fleet), which the UK might expect to share battlespace with.

The Impact of Carrier Capability on Britain's Military Reputation

The size and professionalism of the UK's military force, one of the most capable in the world, significantly contributes to Britain's reputation and status on the global stage. If harnessed correctly, the introduction of a new carrier capability has the potential to boost the UK's standing significantly and send a powerful message of intent not just to potential state and non-state adversaries, but also to allies, particularly the United States, allowing the UK in turn to employ greater leverage on US decision-making. It will also elevate Britain's ranking as Europe's senior military power, allowing it to speak with more authority and lead the debate in both NATO and the EU on defence and security matters.

Carriers in the Humanitarian Role

Global population-growth trends show that a greater percentage will live in densely populated, flood-prone coastal areas where land is cheap and available; it is in these areas that natural disasters, resource conflicts and proxy wars are highly likely to occur. The arrival in theatre of a UK carrier – indeed, its very existence – sends a powerful message in this regard.

The 2010 UK SDSR already highlights the humanitarian-assistance role that the carriers might play; for example, in evacuating British nationals from a hostile situation abroad. Whilst true, it ignores the potential this new capability brings in supporting DfID's wider objective of upstream intervention to prevent possible conflict.¹ According to DfID, for every £1 spent in this way, £4 in savings for the international community is generated.² The ever-closer relationship between the MoD and DfID suggests that the next few decades could see a greater collaboration in the delivery of humanitarian and development aid, going beyond rescuing British nationals or maintaining the ability to do so.

Although some NGOs still distance themselves from working with military personnel, recent natural disasters in Haiti, Indonesia and Japan have illustrated the versatility of armed forces around the world in providing aid, while climate change leading to critical food and water shortages and mass migration points towards greater instability, particularly in Africa. Britain already has an enviable international reputation in responding to aid crises. The contribution that carrier-based assistance could provide (paid for by DfID, providing it met OECD guidelines) deserves further debate and would not go unnoticed by the wider international community which the UK seeks to influence. It is a role often exploited in the past, predominantly from the sea, but is likely to be of increasing importance over the coming decades.

Technological Proliferation

Historically, the technological gap between Britain and its adversaries has predominantly given it the upper hand in battle (although some poor decision-making has seen that advantage squandered). That gap is closing as both state and non-state aggressors gain access to similar technology or understand the UK's doctrines and procedures, and then quickly adapt their own skills. Meanwhile, conflict is, in essence, evolving and not becoming any simpler; indeed, the range of threats is actually expanding.

The UK's response must be to deliver a broad utility. The development of one of the world's largest-ever carriers available for use in the littoral role (a fact not fully appreciated by Parliament) provides a rare opportunity to re-write the rules on agile, expedited, technologically advanced, independent (or multilateral) engagement – but only if traditional carrier wisdom is further developed, emerging technology is harnessed and inter-service rivalry is removed.

Once operational, the *Queen Elizabeth*-class carrier task group³ is likely to be one of Britain's first assets sent towards a developing hostile environment – a powerful political statement of deployment synchronised with a diplomatic scheme of advance. Additionally, operating 12 miles off the coast in international waters, its deployment would avoid the need for potentially complicated, expensive and rushed forward-basing requirements.

Pressure on Financial Budgets

The global recession of 2008–09 represented a body blow to the financing of many armed forces around the world, most significantly to those of the US, which will see a minimum of \$400 billion in cuts to defence spending over the next ten years.⁴ In Britain, pressure to balance the books after so many years in the red has seen key procurement projects cancelled or delayed, impacting all three services for over a decade.

The appalling press surrounding the carrier procurement deterred any thought of export potential, not least because only eight countries are in this market. Once again, however, this is to look at the challenge through the lens of today and not that of a decade or two from now when Germany, Japan, Spain, Brazil, Turkey and, indeed, France and the US could look with interest at how this new class of carrier functions. The *Queen Elizabeth* carriers are cheaper than the *Nimitz* and *Ford* classes, but come with more options than the *Wasp* and *America* classes.

Essentially, the same buzz that is developing around the Type 26 Global Combat Ship needs to be generated around the UK carrier; this must be a project eagerly followed, not tucked behind the scenes until the ships are launched. There is an opportunity to showcase British industry and innovation, to turn a project associated with political football into one of success and vision beyond the current Parliament.

Notes and References

1. Department for International Development, Foreign and Commonwealth Office, and Ministry of Defence, 'Building Stability Overseas Strategy', July 2011, <<http://www.dfid.gov.uk/Documents/publications1/Building-stability-overseas-strategy.pdf>>, accessed 27 August 2013.
2. Department of International Development, *Eliminating World Poverty: Building our Common Future*, Cm 7656 (London: The Stationery Office, July 2009).
3. The carrier will rarely be deployed as a single vessel, but as part of a larger maritime task force.
4. Department of Defense, 'Defence Budget Priorities and Choices', January 2012, <http://www.defense.gov/news/Defense_Budget_Priorities.pdf>, accessed 27 August 2013.

II. The Case for Two Carriers

Carrier-Enabled Power Projection

A carrier task group can swiftly and independently manoeuvre, free from restriction, through the international waters which cover two-thirds of the planet. Its small, isolated footprint means it is less vulnerable to insurgent attacks or interference from local populations. Indeed, it is independent of direct host-nation support or caveats and combat-ready at the point of arrival.

The *Queen Elizabeth* class is over three times the size of the *Invincible* class, with a crew of up to 1,600, a range of 8,000 nautical miles (without re-fuelling), as well as the ability to move around 500 miles a day and operate a mix of up to forty air platforms. The carrier's agility and independence means it is likely to be one of the first assets deployed to any hotspot around the globe.

To date, key decisions about how the carriers will operate – not just strategically in the context of the rest of the armed forces, but operationally as a task group – have yet to be taken. Yet there is a narrowing window of opportunity to procure equipment, develop protocol and train personnel in order to maximise the early potential of this unique class of carrier.

Current Government Thinking

The annual cost of running a second carrier is estimated to be £65 million, but under current MoD assumptions there are no plans to run the two carriers concurrently, and a final decision is planned for the 2015 SDSR. According to the 2010 SDSR, the present options include:¹

1. Placing the second carrier in 'extended readiness', leaving the option to rotate both carriers to either maintain 'a continuous carrier-strike capability' or to regenerate more quickly a two-strike capability
2. Selling one of the carriers, relying on co-operation with a close ally to provide a continuous at-sea, carrier-strike capability
3. Operating two carriers concurrently.

Following the considerable impact of the last SDSR on Britain's armed forces, which have since continued to be tested in two theatres of war, the government should recognise the need to review the decision not to run two carriers concurrently. The government should recognise the operational requirements that a second carrier will have on both ships and, by relating this to deployment, equipment, manning and training cycles, recognise the need to make a decision about the second carrier soon.

A £3-billion carrier waiting in 'suspended animation' in Portsmouth to be activated has political consequences, as does the selling of a ship at a loss. Neither option is a sensible use of taxpayers' money. Indeed, the latter should

be firmly disregarded; the UK either needs a carrier capability or it does not. If it does, then a minimum of two are required in order to have one permanently available. The assumption that the UK could develop absolute alignment in both foreign policy and carrier availability with the French is not practical.

Key Carrier Roles: Littoral and Carrier Strike

Aircraft carriers have, since their introduction during the First World War, developed two specific roles: carrier strike and littoral manoeuvre.

In the first, the carrier is typically part of a larger formation, usually including destroyers, frigates and submarines, as well as logistical-support ships. The carrier provides the primary offensive air power, while the other vessels provide the wider defence and support role and can also participate offensively, such as with the launch of missile systems. Carrier-strike groups are often formed for a specific mission rather than by platform.

In the littoral role (from the Latin *litus*, meaning beach), the carrier can also be part of a wider task group and contribute to amphibious assault capability, with its coercive force comprising land forces as well as aircraft working together. In the US, this role is the preserve of the Marine Corps which not only makes up the large expeditionary component, but also flies a combination of rotary-wing, tilt-rotor, and STOVL and VTOL (Harrier) aircraft. The US assault ships usually include a well deck (the hangar-like deck located at the waterline), allowing boats, amphibious vehicles and landing craft to dock within the ship. The *Queen Elizabeth* class does not have this facility and new protocols to offload Royal Marine personnel and equipment should be developed now in order to incorporate any small design changes as the ships are being built.

Given these two discrete missions, elements can, in theory, be combined depending on the mission objectives and involvement of the carrier through the phases of war – from winning the engagement, through stabilisation to peacekeeping.

The escort group of surface ships, support vessels and submarines is not fixed and will vary depending on the threat assessments of the mission. It is recognised, however, that running two full carrier groups simultaneously would be a challenge, given Britain's present fleet size. In such scenarios of high-threat crisis, one or both carriers would invariably be part of an international coalition with support from US or other NATO allies, and this also provides an opportunity to progress the European Carrier Group Interoperability Initiative to develop a credible 'second task group' mentality built around a second UK carrier. However, the political, economic and military ramifications of having only one carrier must not be underestimated

while the development of marinised UAS offers an additional layer of carrier defence, as explored in Chapter V.

Additionally, whilst carriers can be targeted by various weapons systems, a sense of proportion is needed. A carrier operating 100 miles from the coast can increase its 'area of uncertainty' from its point of origin by 400 square miles in the first hour, by 1,600 square miles in the second hour, 3,600 square miles in the third hour and so on until the area of uncertainty is over 60,000 square miles by the end of a twelve-hour period. This area, even if the carrier were at its furthest point from origin, is still only 300 miles from the coast and thus, with air refuelling, is within useful striking range of land targets while all but the most advanced long-range weapons (such as the Chinese DF-21 missile) are negated. Even the DF-21 requires accurate targeting data that assumes a high level of technological resilience for satellite or survivability and tracking capabilities for submarines. In comparison, the expeditionary land airfield – a fixed base – is highly susceptible to cheap and accurate saturation attacks by simple, armed UAS that could disrupt or deny air operations from such fixed sites.

However, a carrier is not invisible and whilst tactics, deception and escorting aircraft, ships and submarines with advanced sensors and weapons can mitigate the threat, carriers are not invulnerable. As an overt demonstration of national intent, the aircraft carrier would make a prized target for an enemy. The increasing benefit to the UK and Western coalitions of the UAS will thus, by default, be exploited by an adversary to try and locate, track and possibly attack the carrier. Two hulls would reduce the strategic vulnerability of a single hull and when incorporated into the wider land and maritime balance of deployed forces, would provide an adversary with another targeting challenge in order to counter this multifaceted capability.

Key Deployment Roles

The strategic intent of carrier capability is a very-high-readiness operational capability, able to contribute to the UK Response Force Task Group, a likely core component of the UK Joint Expeditionary Force in the future – which will be forward deployed and used as a tool of influence, coercion and, ultimately, physical power projection using air, ship and land power from the sea. The carriers' three distinct roles would be:

1. Delivery of carrier strike in simple or complex interventions from the sea, including:
 - Command and control
 - ISTAR
 - Deep strike – both fixed-wing aircraft and submarine-launched, tactical land-attack missiles

- Close air support
 - Submarine warfare and mine countermeasures
2. To conduct amphibious operations (with or without fixed-wing aircraft), including:
 - Littoral command, with or without combat air support
 - Special-forces insertion
 - Amphibious raiding operations
 3. To undertake non-combatant operations, including:
 - Search and rescue
 - Evacuation of entitled personnel from crisis areas – opposed or unopposed
 - Humanitarian assistance and peace support
 - Disaster relief
 - Diplomatic engagements, aimed at achieving wider influence.

The Size of the Air Fleet

A recent MoD review of carrier utility was prohibited from addressing the principal questions of the number of carriers required and service ownership of the fixed-wing assets.² Instead, it focused on the size of fleet, the number of sorties and deck tempos, with the planning assumptions of:

1. Carrier strike:
 - Twelve to fifteen F-35B JSF aircraft for 'routine' embarkation
 - Twenty-four aircraft 'surge' on every deployment cycle to 'stress' the deck and to practise and prove the most demanding aspect of carrier operations (a maximum of thirty-six F-35B aircraft are designed to operate from the carriers)
2. Littoral role:
 - A minimum of six aircraft
 - Other rotary assets yet to be determined.

Limitations on the Size of the Air Fleet

If the standard size of an F-35B squadron on board the carrier is twelve aircraft, this equates to just twenty sorties per day, using only 24 per cent of the design capacity of the ship and providing a challenge in maintaining the currency of both pilots and the ship's crew, as air and deck-crew qualifications would lapse. The availability of a second carrier would offer the possibility

of all-year-round carrier availability and therefore the ability to remain proficient in carrier-strike and littoral-manoeuve roles concurrently.

Determining aircraft fleet size before more of the fundamental questions have been answered does not make sense. The 2012 MoD review is the first to speculate on what effect the UK wants to achieve, rather than what vehicles or methods it currently uses that could be slid across to the new *Queen Elizabeth* class. However, no helpful conclusions can be drawn if the actual number of carriers has yet to be decided.

Should the second batch of F-35 aircraft procured for the UK be the F-35A variant, as the RAF desires in order to fill the Typhoon-replacement requirement, this will have considerable implications for the UK in terms of cost and capability. First, being a conventional variant, the aircraft could not operate from the deck of the *Queen Elizabeth* carriers and instead requires a 3-km runway. Secondly, the aircraft does not have as standard an air-refuelling probe that allows the pilot to connect to a trailing hose; it has a receptor behind the cockpit that requires a solid 'flying boom' operated by a trained operative in the air-refuelling tanker itself. This system has never been used by the UK before and will require significant modifications to the new fleet of Voyager refuelling aircraft, plus training and sustainment, to provide this niche requirement.

Carrier Deployment Cycle with One and Two Carriers

A single carrier would be limited in both availability (to around 200 days per annum) and role. As both carrier strike and littoral manoeuvre require regular embarked periods to validate and maintain role-specific currency, a single ship would be in a perpetual re-role and programme conflict.

Whilst it is feasible for a single carrier to operate in carrier-strike and littoral-manoeuve roles in a single cycle of eighteen months, there will be increased programme challenges for the air assets, particularly in the littoral-manoeuve role where a greater number of disparate enablers are required to come together. Additionally, the highest level of training development cannot be achieved for both littoral-manoeuve and carrier-strike roles in any period with a single available ship, thus limiting the UK's ability to deliver carrier strike and littoral manoeuvre or – if one role is required – necessitating one of the roles to atrophy. Also, every five to eight years a single ship would be removed from the schedule due to routine (but extended) maintenance.

The full and concurrent utilisation of the second carrier would allow both roles to be maintained simultaneously whilst enabling a higher level of proficiency in both roles for a greater period of any cycle. The second carrier would also allow for ship maintenance cycles to be alternated and therefore maximise availability when one carrier enters a re-fit period.

An overall availability of 350–400 days per year between the two carriers would allow both carrier strike and littoral manoeuvre to be maintained at a higher level and for an extended period.

Selection of Other Carrier-Borne Aircraft and Ordnance

As already stated, the debate over F-35 variants has overshadowed other critical aspects that the UK carrier capability might develop, particularly in both the carrier-strike and littoral-manoeuvre roles. In the latter case, there are aspects that could be put into practice (or at least trialled) when HMS *Ocean* comes out of re-fit in 2014.

Impressive though the F-35B is, in the kinetic context it is just one platform for delivering a form of ordnance. As Chapters IV and V explore in more detail, there may be cheaper, more effective ways of delivering the same ordnance or, indeed, more suitable bombs or missiles than those used by the Tornado, such as Storm Shadow or Dual-Mode Brimstone, but which are presently incompatible with the F-35B.

The Apache, for example, which performed its first-ever marinised role during Operation *Ellamy*, and has already been earmarked for use on the *Queen Elizabeth* class, could offer a cheaper alternative in delivering Brimstone, but plans to upgrade the Apache to fire this ordnance have been delayed. From the standpoint of ship compatibility, there is presently no plan to introduce automated or manually folding rotor blades to the Apache for efficient aircraft storage. This means that any visiting Apache must either remain on the deck – exposed to the corrosive salt air – or the blades must be manually folded for storage below decks.

This suggests that the full spectrum of carrier capability is not being explored; or, if it is, not by relating the discussion to a value-for-money argument. The 2010 SDSR boldly lists an impressive number of helicopters which might be used in a future littoral role but, like the Apache, many are ‘green’ (army) rather than ‘grey’ (marinised Royal Navy) aircraft and will be quickly degraded or even written off if measures are not taken to make them more seaworthy, such as the use of protective paint schemes suitable to the marine environment.

Finally, there is no industry remit from the government to procure a marinised drone capability for the *Queen Elizabeth* carriers. Considering the pace at which UAS technology is developing, this is surprising. Yet such marinised assets have already entered service in the US, Germany, Italy and France and are currently being trialled by the Swedish navy.

Absence of Long-Range, Persistent ISTAR

However justified the decision to cancel the Nimrod surveillance aircraft may have been, it has removed a long-range and persistent ISTAR capability

from the UK's arsenal, which will have an impact on the use of the carrier(s). Britain is now lacking a long-range, persistent nodal point for the entire battle theatre which can facilitate the flow of all digital data, information and communications. As such, the MoD is presently conducting an Air ISTAR Optimisation Study in conjunction with Niteworks to inform the future provision of ISTAR.

For the moment, Crowsnest will deliver the carrier-borne ISTAR capability using modified versions of the EH101 Merlin. However, a longer-term solution is urgently needed.

Single-Service Ownership of the JSF

Another debate taking place behind closed MoD doors is which service will own the carrier-based JSF. Conventional wisdom dictates that all maritime assets be naval cap-badged; however, the line between the RAF and the Royal Navy was blurred under the last government with the formation of the single Harrier command structure. Called the Joint Force Harrier, it combined the Royal Navy's Sea Harrier FA2 (previously under Naval Air Command), the RAF's GR7/7A, and the upgraded Harrier GR9 all under the umbrella of RAF Strike Command. The removal of all Sea Harrier aircraft under the Labour government in 2006 left the RAF responsible for UK carrier-strike aircraft, thereby removing the airborne element of ship defence – a deficiency not seen in any other carrier-operating nation. Present government thinking points towards the new F-35B force being jointly delivered by the Royal Navy and the RAF.³

The carrier is designed to fly seventy-two sorties a day based on thirty-six Force Elements at Readiness. The Royal Navy says it can meet this embarked tempo for a single carrier for 7.5 months in every year. The RAF's response is just four out of twenty months.⁴ This suggests that sole Royal Navy ownership of the carrier-based JSF would provide a more enduring strike capability with greater availability for operations from the amount of money invested in F-35B, with no loss of operational capability as training for the vast majority of the missions flown by the F-35B can be executed from the sea base.

The Use of Royal Marine Commandos in Defining the Carrier's Littoral Role

The Royal Marines have a global reputation as one of the most able and professional units in the world; 38 per cent of first-echelon UK special forces are recruited from the Royal Marines. Although commando recruitment and basic training has remained marine-focused, 3 Commando Brigade's frequent tours to Afghanistan and the reduction in the number of assault ships and carriers has meant that traditional skill sets have atrophied. The conclusion of Britain's operational commitment in Afghanistan and the pending arrival of the *Queen Elizabeth* class provide an opportunity to restore those particular and specialist skills.

In designing a future Response Force Task Group, there is a necessity to develop new commando doctrine and protocols that can complement the jump in capability that the new carrier(s) will offer and help to define the ship's fighting capability and, indeed, reputation. This will only be possible if the marine transport assets, which include rotary-wing aircraft, are identified and, if necessary, altered to ensure reliability and relevance at sea.

The Variant of the Final Batch of JSF Yet to be Determined

To compound matters, despite the defence secretary's recent statement recommitting the carrier to the F-35B variant,⁵ this only applies to the first batch of forty-eight aircraft. This leaves the door open for the final batch to include some or all of the apparently cheaper F-35A land-based variants.

This solution would provide the RAF with its own dedicated 'beyond radius of action' aircraft, provide a successor to the Typhoon (which is due to come out of service in 2030) and resolve the tussle with the Royal Navy. However, there is only 20 per cent commonality between the two variants and running essentially two new, separate platforms would be considerably more expensive (circa £2 billion more through-life) than procuring a single F-35 JSF variant. Again, these important decisions have been pushed into the long grass until the next SDSR. A single force of F-35B would offer the most flexible expeditionary capability – from sea and land – and for the least investment.

The Costs of Running a Second Carrier

The fact that the annual running cost of RAF Marham is £144 million) places the bill for a second carrier into perspective. Yet few decisions are as strategically significant as that regarding the *Queen Elizabeth*-class carrier and many parliamentarians would support the annual £65 million bill were they aware of the arguments such as the likely long-term savings gained via a guarantee of avoiding another land-based air campaign,⁶ as the next chapter shows. For the same effect, land-based air support (such as that required for Operation *Ellamy*) is around six times more expensive than carrier-based air power. These are compelling reasons of value for the government to review the arguments in favour of operating a second carrier.

Notes and References

1. HM Government, *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, Cm 7948 (London: The Stationery Office, 2010), p. 23.
2. Edward Ferguson review, 2012.
3. *Hansard*, Written Answer to Question 123580, 25 October 2012, Col. 967W.

4. Limits to the length of time personnel can be deployed vary between the three services. The Royal Navy has a '660/3' rule, which is a rolling total of 660 days away from the home port or base in three years. This equates to around seven months of every year, but can be aggregated to allow for a longer period (the 7.5 month example used assumes three weeks transit to and from the UK to allow six months 'on station' in theatre), or out to nine or ten months if more time is required on station. The RAF plans on personnel being deployed for no more than four months in any twenty-month period. In theory, once a four-month deployment has occurred, personnel cannot be deployed again until sixteen months hence. It is worth noting that this guideline has been broken by the RAF during the Afghanistan campaign in order to get the job done, but the planning assumption remains.
5. Philip Hammond, 'Carrier Strike Capability', *Hansard*, HC Debates, 10 May 2012, Col. 140.
6. *Ibid.*, Col. 145.

III. Learning from the Libya Campaign

Operation *Ellamy* was the first serious campaign for the UK's armed forces since the 2010 SDSR and therefore a campaign worth reviewing, especially from the perspective of marinised operations. A number of NATO reports have been subsequently written from which the following themes are applicable to this paper.¹

Allied Commitment

Although thirty-six nations supported UN Resolution 1973, just sixteen stepped forward to provide military assistance. Whilst seen as a NATO-led operation, Germany's and Poland's decisions not to participate and the United States' unusually reserved role illustrated that the level of commitment on the part of natural allies cannot be taken for granted. This poses difficult questions for the Alliance in planning and training for future operations. Not knowing which allies can be relied upon hinders the development of the country specialisation that can be brought to the NATO table, and also places additional burdens on those allies that do choose to step forward. How different this operation would have looked had Italy joined Germany and denied access to the forward air base of Gioia del Colle.

A Cautionary Approach

To avoid repeating the strategic and operational mistakes which led to 'mission creep' in both Iraq and Afghanistan, a series of measures were taken that are likely to influence political thinking relating to future operations. These included:

- Engagement given a legal footing by the UN
- A NATO-led, multilateral approach
- Enforcement of a no-fly zone
- A commitment to actively and overtly protect civilians
- A refusal to place coalition boots on the ground
- Precision targeting to minimise collateral damage
- The supporting and arming of friendly local forces (mostly by proxy).

The drawback of this arm's length approach is the reliance on local ground forces – which will often be disparate, poorly trained and ill-disciplined – to defeat an adversary which, in the case of Libya, involved professional forces. This disconnect between the air and ground campaigns, both, in effect, operating in isolation, resulted in a long, drawn-out campaign. Whilst this gave opposition leaders time to make post-war plans, it dramatically increased the overall cost of the war.

Maritime Contributions

Within an impressive thirty-five minutes of the UN resolution being signed, the majority of the Libyan air-defence network had been destroyed thanks

to Tomahawk missile strikes by US Navy warships and the Royal Navy submarine HMS *Triumph*, supported by Harrier AV-8B aircraft flown off the pre-positioned USS *Kearsarge* (a *Wasp*-class carrier). The USS *Kearsarge* provided critical airspace command and control, including de-confliction of allied air movement. This was shortly followed by air strikes by Rafale M jets from the French carrier *Charles de Gaulle*: the first non-US aircraft over Libya.

Ninety-five per cent of the strikes in this initial phase of the destruction of recognised military targets were executed by the US. Once complete, the operational requirement switched to kinetic, tactical targeting that relied upon quick response as targets were identified – often on the move – and so the opportunity to strike was brief. The USS *Kearsarge* was withdrawn and, until the arrival of the French carrier, the sustained phase of operations was conducted by planes flying from bases in France and the UK, requiring multiple instances of mid-air refuelling. The French carrier proved to be particularly adept in exploiting fleeting targets due to an embarked commander in the carrier with the authority to make such decisions; the use of embarked French Hawkeye; the positioning of the carrier close to the coast to reduce response times; and the use of practised targeting procedures.

Mission Accomplished without UK Carrier Capability

As postulated in the 2010 SDSR, Operation *Ellamy* proved that it is indeed possible to successfully and significantly contribute to a multilateral engagement without the use of a carrier. However, the government must concede that *had* such an asset been available it would have been put to full and effective use.

In addition, there were significant consequences to running a forward land-based air campaign, which place into perspective the contribution carriers could have made. These included:

- Decreased alert times: an inability to respond at short notice to developments on the ground
- The use of RAF Marham: Tornados had to fly a 4,830-km round trip, requiring five mid-air refuelling operations, until UK logistical support was in place at both Gioia del Colle, Italy and Akrotiri. However, no agreement was reached to store and operate Storm Shadow missiles in Italy, and so this part of the mission could never be forward based
- The use of Gioia del Colle: although this base was much closer to the targets, Tornados still required two mid-air refuelling operations in order to complete their missions. Weekly land convoys were also needed to transport weapons and logistics-support equipment for eighteen jets and 800 personnel. Additional costs included the use of a foreign sovereign base, hotels, hire cars and personnel allowances

- Air-frame fatigue: the large distances flown for such a long period of sustained operations from both RAF Marham and Gioia del Colle have aged the aircraft involved considerably
- Extended command and control: the need to establish a land-based command node, forward-deployed in Italy, added a further layer of command, increased costs and complicated the targeting process.

Land-Air versus Marine-Air Sorties

Although Tornado missions flown from RAF Marham were hailed as a success, there are lessons to be learnt from the detail of how these tasks were executed in comparison with US carrier-based operations:

- For every four Tornados tasked to Libyan airspace, a further two were required to be airborne in order to replace one or more of the four Tornados in case they became unserviceable after taking off
- The cost per flying hour for the Tornado is £32,000, meaning that the total cost per flying mission of thirty hours (four aircraft flying for seven hours, with two additional flying for one) was at least £960,000. This does not include the flight of the VC-10 tanker for over eight hours in support of the missions, or the cost of the ordnance expended
- As a comparison, US Marine Corps AV-8B missions from the USS *Kearsage*, located around 50 miles from the Libyan coast, took about 90 minutes per tasking without a requirement for mid-air refuelling.

A question for the government, following its experience in Libya, is at what distance from RAF Marham does a Tornado deployment become an overtly expensive and unviable option? Libya was a 3,000-mile round trip. Tornados have had eight catastrophic engine failures in recent years, one resulting in a fatality, and the aircraft cannot physically fly beyond eight hours due to the 'release to service' on engine maintenance.

Costs of Land-Based versus Sea-Based Operations

Official government figures report the cost of Operation *Ellamy* to have been £320 million, although it is difficult to qualify separate fixed costs versus additional costs of the campaign. Written evidence for the Defence Select Committee calculates the cost to be far higher at £1.35 billion and estimates an equivalent sea-based air cost of £245 million.² MoD evidence seen in research for this paper estimates the cost of land-based air costs (at a distance of 600 miles) rising to four times that of carrier-based operations.

The government may argue that such calculations are irrelevant; there was, after all, no carrier strike available. The last time Britain operated carrier strike was in 2004. Therefore studying how, first, the *Queen Elizabeth* class might have contributed (either as a single-carrier task group or with two

carriers available) and, second, how HMS *Ocean's* performance might be enhanced could prove beneficial.

In summary, Operation *Ellamy* illustrated the enormous costs incurred in relying upon forward land basing and long-range sorties to conduct air strikes. The deployment of Apache also showed how the littoral-maneuvre and carrier-strike roles are becoming increasingly interdependent. Only by operating two carriers simultaneously would Britain be able to guarantee a continuous carrier commitment – unlike France, which had to withdraw the *Charles de Gaulle* from Libyan waters in August 2011, two months before the mission was completed.

Joint UK-US Experimental Carrier-Force Unit

From a wider perspective, it is clear that both the UK and the US have much to consider in maximising the use of the *Queen Elizabeth* and *America* classes, respectively. Serious thought should be given to formalising the already established close co-operation on carrier training by establishing a joint, experimental carrier-force unit that would assist both countries in developing future carrier-strike and littoral-maneuvre capability.

The unit could take responsibility for developing future UK carrier manpower skills as well as the modelling and simulation of the *Queen Elizabeth*-class deck cycles, mixes of F-35B aircraft, rotary-wing aircraft, embarked (marine) forces and the integration of future UAS.

Notes and References

1. See, for instance, NATO Joint Analysis and Lessons Learned Centre, 'Operation Unified Protector: Lessons from National Military Perspectives', February 2012.
2. House of Commons Defence Select Committee, 'Evidence by Admiral Sir John Woodward to Defence Select Committee's inquiry into the effectiveness of the operation and UK Forces' role in Libya', 7 February 2012, <<http://www.publications.parliament.uk/pa/cm201012/cmselect/cmdfence/950/950vw09.htm>>, accessed 27 August 2013.

IV. Missile Systems

Considering the significant role that a bomb or missile plays in achieving the ultimate objective of accurately destroying a target, one could argue that its function is more important than the platform which delivers it. Thus neither the delivery mechanism nor the weapon itself should be taken in isolation, but as an entire process through which to achieve an outcome.

Yet in Parliament and the MoD, the debate surrounding weapons procurement plays second fiddle to the delivery hardware, possibly because the systems are becoming ever-more technical. More likely, however, it is because there is little human interface; pilots fly the planes and sailors man the ships – the weapons systems are simply the bells and whistles that are strapped on to the more familiar delivery platforms. Of course this is to oversimplify, and the UK armed forces use many weapons systems that are state of the art. Yet industry receives little strategic guidance about weapons procurement because it is not fully co-ordinated across the services (or, indeed, across NATO) and is not viewed in the wider concept of operations.

To illustrate the haphazard approach to munitions procurement, no formal decision was ever made to allow Storm Shadow or Dual-Mode Brimstone – the UK's principal air-launched, advanced missiles systems – to be deployable from the Harrier, Typhoon or the JSF. Yet for the next decade, these systems will form the backbone of Britain's long- and medium-range air-to-ground attack capability. Excluding systems which personnel (both pilots and ground support) are familiar with only makes sense if they are now obsolete and successor systems will be compatible with other platforms such as the Apache – yet this does not seem to be the case.

All three services are also prone to thinking independently, rather than sharing procurement processes on systems which may have a potential role in another service. The Fire Shadow, for example, is a loitering weapon system which was developed for deployment in Afghanistan following successful trials by the army. With a range of 100 km, it is surface-launched off a short ramp fixed to a trailer and can remain airborne for up to six hours, enabling a precise and rapid attack once a target is identified. This not only has potential on board a carrier, but indeed on board other ships such as the Type 45, where deck space is at a premium. Yet the Royal Navy had no involvement in Fire Shadow's procurement.

Developing a Family of Compatible Systems

There will of course be tailor-made systems that are not compatible on all platforms. However, this should not prevent a more cognitive approach, specifically regarding precision-guided, ground-attack systems. Thales, for example, is developing a 5-kg air-to-ground attack GPS-guided weapon –

but for the defence industry at large, rather than for the UK. Such a system would provide a far cheaper option (at around £10,000 a unit) for removing mobile targets, such as light patrol vehicles or civilian 4x4s armed with heavy machine guns, than Dual-Mode Brimstone missiles, which cost £150,000 a unit. This is not to argue that one should replace the other, but that a greater choice should be made available to the local commander.

The *Queen Elizabeth* carriers will include a highly mechanised weapons-handling system and provide extremely efficient automated stowage and retrieval of ordnance from the ship's magazine. This offers a sterling incentive to develop a common series of weapons, which could be deployed on a range of air platforms (fixed wing, rotary wing and UAS) expected to operate from the carrier. This would simplify weapons storage and management as well as reduce costs. The more types of munitions required, the fewer the numbers of each category stored on board and the more qualifications needed by loaders licensed to handle them.

V. Air Assets

Present thinking suggests that three aircraft types will be routinely based on board the *Queen Elizabeth* class in varying numbers for both littoral and carrier-strike roles. These include the F-35B, and the Merlin (Mk2 anti-submarine warfare; Mk4 maritime air assault; and Crowsnest ISTAR) and Wildcat helicopters. All three types are designed to fly in the harsh maritime environment; otherwise, exposure to the salt air would have a corrosive impact on engines rotors and airframes. In addition, the Chinook and Apache would also be expected to be deployed on board. These 'green' aircraft are not designed for the sea environment, and consequently they can only be deployed for short periods. Additionally, the lack of blade-folding mechanisms restricts their utility and reduces the flying output from the deck.

Yet tasking green helicopters to sea at short notice should be avoided. As the deployment of the Apache during Operating *Ellamy* showed, it incurs large costs to repair (or replace) the aircraft after exposure to the harsh sea environment. If it is likely that an air platform might be deployed on board a carrier, then it must be factored into the bigger picture of the capability of the carrier group and changes made to the aircraft to optimise it for short- or medium-length operations at sea. The allocation of previously un-integrated aircraft to a deployed carrier would also present a number of challenges.

As illustrated in Chapter II, the operational tasking of the carrier will involve long- and short-distance air and ground warfare; the transportation of logistics-support equipment, military personnel and civilians; and reconnaissance and ISTAR. The fleet of potential air assets, both manned and unmanned, that might be deployed on the carrier by 2020 is growing, and the MoD should determine how the variety of operational roles could be undertaken with future capability in mind. There remains time to adapt current airframes, or to specifically procure new platforms, rather than apply what is available today and hope that obsolescence is avoided.

In the case of ISTAR, where Britain has a long-term capability gap, innovative ways to deliver the capability need to be developed; this should be a combination of maximising the use of current sea-going air platforms and drones. The operation of Hawkeye from the *Queen Elizabeth* class is no longer an option; meanwhile, the US Marine Corps has been impressed with the Crowsnest capability, which could offer UK export opportunities.

UK Rotary Assets

There are currently eleven different helicopter platforms in operation across the UK armed forces (the Apache, Merlin, Scout, Gazelle, Lynx, Wildcat, Squirrel, Puma, Chinook, Sea King and Bell 212) – arguably, too many types for the size of the armed forces and with considerable overlap in

performance and operational capability. This reflects the historically siloed service approach to procurement, which thankfully is now being addressed.¹

By 2014, this will reduce to the Royal Navy operating the Wildcat and Merlin (the latter ultimately performing three roles from the same platform); the RAF (in support of the army and Royal Marines) operating the Puma and Chinook; and the army operating the Lynx, Wildcat (reconnaissance variant) and Apache.

Reviewing the Use of Apache, Merlin and Wildcat

Annex B summarises the operability of these helicopters – all three of which are individually impressive but their siloed procurement processes means that their respective ordnance (which would need to be stored on board the carrier) is not fully cross-compatible, and each lacks aspects which could improve its utility. For example, the Apache can fire Hellfire missiles, but is not marinised; the Merlin can fold its rotor blades, detect submarines and drop torpedoes, but cannot fire any rocket or missile systems; and the naval Wildcat can fire a range of weapons systems, including dropping torpedoes, but comes with a manual folding-rotor capability meaning slower movement below deck and storage. There is time to alter designs – or to make provision for them in future – and increase versatility. The 2010 SDSR suggests that up to eight Apaches might be placed on board the *Queen Elizabeth* class, and a minimum level of marinisation is achievable in the timeframe at a reasonable cost.

Deploying Other Helicopters in the Littoral-Manoeuvre Role

Careful thought should be given to the other types of helicopters that might be required on board the carriers. Again, the 2010 SDSR states that twelve Chinooks could be deployed from the carriers but, as is known from the Libyan experience, they are too cumbersome to move to and from the hanger and their resultant exposure on the flight deck could cause extensive damage unless deployed for a very short period. The presence on board of helicopters without a blade-fold mechanism prevents concurrent jet and helicopter operations and severely restricts operations at sea in general – both in terms of managing the deck and maintaining the aircraft in the open.

Unmanned Aerial Systems

The revolution taking place in UAS technology continues to impact on the ways in which war can be prevented and conducted. Although a number of systems – both passive and kinetic – have already been procured by the MoD, to date there are no UK-funded UAS projects specifically optimised for use in, and from, the maritime environment. This must change. Without a doubt, unmanned technologies will play a major role in the maritime domain in the longer term and it seems bizarre, given the long lead time, that UAS effect will not be included as part of the UK's carrier capability from the outset.

The UK has invested in a number of UAS including the Thales Watchkeeper, General Atomics MQ-9 Reaper, and BAE demonstrators Taranis and Mantis. As Annex C considers in more detail, there is an abundance of land-based unmanned systems which could potentially be marinised for carrier use, though the change to the STOVL-variant JSF has meant that the deck layout places greater restrictions on the launch and recovery of the unmanned aircraft.

Despite defence-industry interest (and consequently advances) in land-launched systems, a number of maritime solutions have been explored. Sweden, France and Germany, for example, operate the Schiebel S-100 unmanned helicopter in the ISTAR role. Meanwhile, the US, which has a number of naval UAS programmes running, has cleared the Northrop Grumman MQ-8 Fire Scout for deployment with its *Wasp*-class carriers.

The MoD needs to understand how a maritime UAS capability would enhance the carrier's operational potential in command and control, surveillance, search and rescue, (deeper and more persistent) strike, force protection and casualty prevention.

Allied Military Assets Contributing to the *Queen Elizabeth* Class

In matching assets to tasks, potential contributions from the UK's close allies should not be ignored. If NATO nations are willing to share forward land bases for international military campaigns – as the Italians did during the Libya campaign – then thought should be given to recognising which assets might add operational value to the *Queen Elizabeth* task group, either in strike or littoral-manoeuvre roles. For example, two other countries are signed up to procurement of the F-35B, potentially enabling co-operation with them, and the US Marine Corps Sea Cobra (AH-1Z) or French Tiger attack helicopters could easily be accommodated on board the carrier for short periods if preparatory arrangements were made.

Notes and References

1. Ministry of Defence, 'Defence Rotary Wing Capability Study', June 2012.

Conclusion and Recommendations

The *Queen Elizabeth* class, when operational, will become the centrepiece of Britain's military capability, significantly impacting all three services and enhancing joint effect. Strategically, it will extend and embolden Britain's diplomatic, soft and hard power in a manner not seen for a generation.

Yet this size of vessel (four acres of mobile military operating base) has no present reference upon which to build.

The last time the Royal Navy operated fixed-wing aircraft from a carrier was in 2004, and that experience is now obsolete. To compound matters, for the last decade, military priorities, thinking and resources have rightly focused on counter-insurgency warfare in Afghanistan. Whilst important work is taking place to prepare for the arrival of the *Queen Elizabeth* class, political thinking and consequently decision-making has not woken up to the enormous generational opportunity it will bring.

By adapting modern, state-of-the-art capabilities for the maritime environment, Britain has the capacity to develop a potent maritime capability able to complement (and not replace) the role played by its land-based fast jets in all four phases of war.

The UK must look beyond the conventional role a carrier offers and think not of platforms but of capabilities (including those of allies) that are able to adapt to the ever-changing character of conflict. It must be quickly recognised that cutting-edge carrier capability rests not just with the F-35B, but with appropriate assets that will complement this fifth-generation aircraft to guarantee it becomes the new standard in carrier operations, wherever it is put to task in the world, regardless of the mission – from supporting war efforts to providing humanitarian aid and building Britain's prestige and influence.

However, the window of opportunity is closing. As this paper highlights, there is a litany of decisions which cannot wait for the next SDSR and must be made now. As HMS *Ocean*'s successful experience in Libya proves, there may be more cost-effective ways to deliver traditional carrier-strike effect if conventional thinking and service rivalry is dropped and the versatility of air assets and advanced munitions are explored – the results of which do not require the arrival of the carriers to be put into practice.

The most significant decision remains whether to make a commitment to the operation of a single carrier or two carriers concurrently. This must be made now as its consequences ripple deep into future procurement, training and operational capability – and, indeed, the very success of the *Queen Elizabeth* carriers and Britain's reputation as a global military power.

Author's Recommendations

- An immediate commitment by the government to the commissioning and operation of both carriers
- Clarity over strategic objectives for the *Queen Elizabeth* class and its use in both carrier-strike and littoral-manoeuvre roles, and how this new capability will impact on existing single-service and joint effect
- Review of UAS that could be marinised and deployed on the carriers
- Confirmation that the carrier-based F-35B capability (including training, doctrinal development and manpower support) will be provided by a single service (the Royal Navy)
- Further consolidation of the family of precision-guided munitions expected to be in the carrier's magazine, which then offers a route to munitions being used by a number of platforms, including UAS
- Following lessons learnt from the Libya experience, review the use of British Army and Royal Navy helicopters likely to play an operational role with the carrier, with a view to improving versatility (including ISTAR and ground-attack capability)
- Under the Statement of Intent for Enhanced Cooperation on Carrier Operations and Maritime Power Projection of 2012, establish a joint US-UK experimental carrier-force unit that would assist both countries in developing future carrier-strike and littoral-manoeuvre capability. The unit should take responsibility for developing future UK carrier manpower skills as well as the modelling and simulation of the *Queen Elizabeth*-class deck cycles, mixes of F-35B aircraft, rotary-wing aircraft, embarked forces and integration of UAS.

Annex A: Timeline of the UK *Queen Elizabeth*-Class Aircraft Carriers

- 1998 The SDR envisaged the carriers' in-service dates of 2012 and 2015.
- 2006 Withdrawal of the Royal Navy's FA2 Sea Harrier.
- 2008 Order finally placed. In-service dates slipped to 2014 and 2016.
- 2009 In-service dates for both carriers pushed back from 2014 and 2016 to 2016 and 2018, respectively.
- 2011 HMS *Ark Royal* decommissioned.
- 2012 Return to STOVL-variant JSF due to rising costs and delays in electromagnetic aircraft-launch-system integration.
- 2014 HMS *Illustrious* to be decommissioned (retaining HMS *Ocean*).
- 2015 Next SDSR, with a decision to be made regarding the use of one or two carriers.
- 2017 Sea trials to begin on the first vessel.
- 2018 Aircraft trials to begin on the first vessel.

HMS *Ocean* to be decommissioned, resulting in the loss to the UK of LPH capability for at least five years until HMS *Prince of Wales* is brought into service.
- 2020 Delivery of Britain's initial maritime strike capability via a single carrier.

Annex B: UK Rotary-Wing Capability

The UK has a number of rotary systems which are already earmarked for *Queen Elizabeth*-class operational use, but to date there are no plans to review their practical use at sea or how their performance might be upgraded to enhance capability, reduce unnecessary long-term spending, and help to shape the UK's response to both hi- and low-tech threats that an expensive platform such as a carrier is likely to encounter.

The short analysis below suggests that there are both opportunities and challenges that must be immediately addressed if the period before the carriers become operational is to be harnessed.

WAH-64 Apache

Cruise speed: 265 km/h; range: 476 km; service ceiling: 10,000 ft

The Apache attack helicopter is fast, agile and has an impressive combat range comparable with the Harrier (556 km). Its impressive service ceiling means that it is easily suited to longer-range air-to-air and air-to-ground roles than its reputation as a close combat attack helicopter would suggest.

The Apache is powerful; its Hellfire missiles can destroy a tank or bunker 8 km away and, as its performance during Operation *Herrick* suggests, the Apache is well protected, with just a single helicopter written off in Afghanistan due to pilot error.

Comment: The Apache was designed as a land-based, anti-armour attack platform and was never intended for use at sea. Breaking away from this mindset and factoring in its ability to operate well above the (height) range of small arms and RPGs, however, it is clear that it offers a versatile and cost-effective option in comparison to a fast jet. The aging Hellfire missile is ill-suited to the engagement of fast-moving maritime or land targets and needs to be replaced by the Dual-Mode Brimstone missile. (For this reason, the US is planning to upgrade its Predator UAS armament with Brimstone.)

However, whilst the five Apaches that flew from HMS *Ocean* during Operation *Ellamy* performed well, exposure to the sea elements took its toll. The helicopter is not easily stored below deck, its rotor blades do not fold at the press of a button (as on the Merlin) and its rear wheel means that the tail cannot hang over the deck side to minimise space used. The MoD is looking at adding emergency floatation devices to mitigate this. With this and further upgrades, the aircraft could turn into an invaluable asset in both carrier-strike and littoral-manoeuvre roles. Without these improvements, the cost of post-

carrier-operation repairs could prohibit any lengthy deployments – inhibiting overall capability and long-term training.

EH 101 Merlin

Cruise speed: 278 km/h; range: 1,050 km; service ceiling: 10,000 ft

The Merlin is a versatile, medium-lift helicopter currently operational in both maritime and land environments. In the troop-carrying role, it can carry twenty-four seated or forty-five standing troops and has been used extensively in Afghanistan as a troop carrier. At sea, it performs a range of roles including anti-piracy/drug-running patrols, surveillance and reconnaissance, search and rescue, passenger and load transfers, and submarine hunting.

Thirty Merlins are currently receiving a £750-million upgrade (from Mk1 to Mk2), introducing a state-of-the-art digital cockpit that allows a greater number of targets to be tracked on or below the sea's surface simultaneously. It will be fitted with enhanced fast-roping facilities for Royal Marine boarding teams. A number of Merlins will receive a further upgrade to provide the additional ISTAR capability required on board the *Queen Elizabeth* carriers.

Comment: With its automatic folding blades, the marinised version is designed for carrier use but at present it is only lightly armoured. An upgrade (including a laser designator) would allow it to fire Hellfire and Dual-Mode Brimstone missiles, which both have a range of over 8 km, placing the aircraft well out of line of sight and at a safe distance from simple ground-attack weapons systems. This might be a cheaper option than upgrading the Apache for deployment at sea – though it should be recognised that the Merlin was optimised as an anti-ship, anti-submarine aircraft with a relevant sensor suite and weapons systems.

AW159 Lynx Wildcat

Cruise speed: 290 km/h; range: 488 km; service ceiling: 12,000 ft

Wildcat is the next-generation Lynx expected to enter service in 2014–15 and will be used by both the Royal Navy (in search-and-rescue and anti-surface warfare roles) and the army (in battlefield-reconnaissance and general-utility roles).

The Wildcat is one of the world's fastest and most-agile military helicopters. The twenty-eight aircraft being procured for the Royal Navy will be armed with CRV7 rockets (with a range of 3 km), Light Multi-Role Missiles and the Sea Skua replacement (with a range of 24 km).

The naval version will also be equipped with a SELEX Galileo Seaspray 7000E active electronically scanned array, 360° full-colour surveillance radar and cutting-edge targeting system – similar to the Apache Fire Control Radar.

Comment: The Wildcat is tasked with operating from frigates and destroyers, but there are currently no plans for a permanent role on the *Queen Elizabeth* class. Yet with its state-of-the-art targeting system, adding more potent ground-attack weapons systems (such as those expected to be used on the F-35B) would be a simple upgrade task. With its auxiliary fuel tanks extending its endurance to over four hours, this would probably be the most cost-effective way to evolve carrier-based, ground-attack capability. It does, however, lack the Apache's protective armour and would need to be more robust if it were to take on a more kinetic role.

Annex C: Unmanned Aerial Systems Development

As with rotary-wing aircraft, UAS have the potential to make a significant contribution to the *Queen Elizabeth* carriers, but again there are no current MoD procurement projects considering what this might be. Yet industry development continues apace and by the time the first carrier is operational, UAS will influence the entire battlefield, as advances in technological systems come on line and the cost of simpler systems falls to match the price range of the wider defence market.

However, advances in maritime-specific systems play second fiddle to those that are land-based – probably because of the complexities in launch and recovery and current operational drivers. Limited operational (deck) space means that fixed-wing solutions are more challenging than the traditional rotary solutions. The STOVL carrier design does present a significant challenge to the provision of a long-range or high-speed UAS: it removes the use of catapults that a UAS might utilise, meaning that the design is geared towards rotary and jet fan rather than fixed wing.

As the summary below suggests, UAS procurement for the Royal Navy could follow two paths: first, adapt existing land-based technology for the marine environment; or second, consider one of the novel sea-based systems being tested or that have already come into service elsewhere. Requirements should, of course, not be limited to the *Queen Elizabeth* carriers alone, but should also take into account capabilities that might operate across other ship types such as the Type 45 and Type 26. Ironically, the MoD's Rotary Wing Unmanned Air System Capability Concept Demonstrator programme is considering this, but its remit does not include operations from the *Queen Elizabeth* class.

Land-Based UAS

General Atomics MQ-9 Reaper (also called Predator B or Guardian)

The Reaper is a UAS capable of remote-controlled or autonomous flight operations as well as deployments commanded by a flight crew. It can carry a variety of weapons including the Paveway II laser-guided bomb, Hellfire and AIM-9 Sidewinder missiles.

Comment: The UK Reaper has been tried and tested in Afghanistan since 2007. The military is familiar with the platform, as well as its munitions; however, the absence of arrestor gear on the *Queen Elizabeth* class would mean a new system for deck capture would need to be procured.

Thales/Elbit Watchkeeper

Watchkeeper is a strip-launched tactical UAS capability comprising ground and air elements, collectively designed to provide imagery and imagery intelligence to unit and formation commanders across the tactical levels of command, within the context of joint operations. It is optimised to operate from prepared strips, although it can do so from semi-prepared strips, allowing further flexible deployment options with no dependencies on fixed infrastructure. The system has a fully autonomous mission and control system, including an autonomous launch-and-recovery system. Watchkeeper provides heightened levels of responsiveness and timeliness through its extended endurance (16–20 hours) and reach (150 km), and a wide array of sensors and a laser sub-system. It has been designed as a flexible and modular system and, as such, enables extensive growth potential and options to allow greater use of this capability to meet changing threat environments and to maximise technological advancements.

Comment: Thales has confirmed that Watchkeeper could be marinised but the MoD has made no request for this to be considered. There is also scope to arm the UAS with a 5-kg GPS-guided missile system.

Lockheed Martin/Kaman K-MAX Unmanned Multi-Mission Helicopter

K-MAX was designed for the remote delivery of supplies to the battlefield, or to civilians in situations involving chemical, biological or radiological hazards. K-MAX is operating successfully in Afghanistan and utilises the Flettner double-rotor design which has two counter-rotating, intermeshing rotors, providing increased stability, especially for precision work in placing suspended loads. It is used by the US, Germany and Lichtenstein.

Comment: The K-MAX's double-rotor design lends itself for use at sea where greater control in hover movements would be welcomed. Whilst it is a certified UAS, at present it has no weapons capability – though the US Marine Corps is now testing its capability at sea.

BAE Systems Taranis

A semi-autonomous unmanned warplane, the Taranis is designed to fly long-distance ground-attack and aerial missions. Whilst it can be controlled by satellite link from anywhere on earth, an ability to launch from and replenish ordnance on a carrier would improve response times.

BAE Systems Mantis

This Unmanned Autonomous System Advanced Concept Technology demonstrator is the world's first unmanned, autonomous aircraft. It is intended to have at least twenty-four-hour endurance and is able to pilot itself and to plot its own course, communicating with personnel on the ground regarding its observations. The prototype first flew in October 2009 in Australia.

Comment: Currently, there is no MoD directive requesting a marinised capability for either Taranis or Mantis to be considered during prototype development. Once any ordnance has been expended, the aircraft would need to be reloaded and the ability to operate from a carrier would reduce response times.

MBDA Fire Shadow

Fire Shadow is a mobile, ramp-launched, loitering-munition weapons system designed for the land domain, with an operating range of approximately 100 km. It offers precision-attack capabilities against time-sensitive static and moving targets with minimal collateral damage. Once launched over a battle zone, it can loiter for several hours before being committed to the engagement of a target.

Comment: The Royal Navy was not included in the procurement process for Fire Shadow, but it is now approved for operation by the British Army. Therefore its potential for use on carriers (and, indeed, on destroyers and frigates) should be considered. The *Queen Elizabeth* class in particular offers a very credible and fast platform for deployment of such low-collateral, precision-strike capability.

Northrop Grumman Long Endurance Multi-Intelligence Vehicle (LEMV)

The LEMV is the US Army's unmanned-airship solution to the persistent ISTAR challenge. It operates a payload of different sensors at 20,000 ft for up to twenty-one days, travelling at speeds of 180 kmh. Hybrid Air Vehicles of the UK is the subcontractor responsible for the airship.

Comment: The LEMV has significant potential as a naval asset. With the ability to maintain station or surge ahead of a fast-moving naval task group, it could become the 'eyes and ears' of the group, supporting and complementing both the tactical and endurance helicopter-based ISTAR assets. Equally, once the task group has arrived in the area, the LEMV could provide significant additional warning time in protection of the fleet and landing force whilst offering ISTAR capability in the littoral area and further inland as tasking chances through phases of operation. There is an option to man the vehicle and treat it in a similar manner to a ship. This would reduce the useful endurance to around five days, but would allow the LEMV to 'replenish' fuel and provisions while underway, much like a ship, by descending and tethering to any suitable ship.

Sea-Based UAS

General Atomics Sea Avenger

The Sea Avenger is a carrier-based design of the Predator C Avenger UAS, procured by the US Navy. Changes in design include retractable sensors,

an internal weapons bay, folding wings for storage and a tail hook to allow operation off an aircraft carrier. It can fire similar weapons systems to the F-35B, stay airborne for twenty hours and has a service ceiling of 50,000 ft.

Comment: Whilst the F-35B requires no arrestor gear, it is not too late to consider installing a simpler, lighter arrestor system, with the Sea Avenger and other UAS in mind. At around a tenth of the cost of an F-35B, the Sea Avenger is pointing the way to the future of unmanned combat and there is the likelihood that an arrestor-gear system will be retrofitted during the lifetime of the carriers.

Northrop Grumman MQ-8 Fire Scout

The Fire Scout is a remote helicopter designed for the US military to provide reconnaissance, situational awareness, and precision-targeting support for ground, air and sea forces. It has a maximum speed of 115 knots and an endurance of five hours. It was built as a derivative of the (Sikorsky) Schweizer 330 SP/333 helicopter. Compatible weapons systems are expected to include Hellfire missiles, Viper Strike laser-guided glide weapons, and the Advanced Precision Kill Weapon System (APKWS), a laser-guided 70 mm (2.75 in) folding-fin rocket. It has a maximum speed of 200 kmh, an endurance of eight hours, a service ceiling of 20,000 ft and a combat radius of 200 km.

Comment: As a quick win, the Fire Scout would be an invaluable asset for the *Queen Elizabeth* class, ensuring that Britain does not fall behind in terms of UAS capability and adding versatility and cost-effective strike capability to a task group. The US is now procuring a larger version, the MQ-8C Fire-X.

Northrop Grumman X-47B

The X-47B is a tailless, fighter-sized unmanned aircraft expected to be delivered to the US military in 2014. Its first flight as a demonstration UAS was in 2011. It has a range of around 4,000 km, a service ceiling of 40,000 ft and is able to carry the same ordnance as the JSF. Its ability to operate from an aircraft carrier is now being tested.

Comment: As with the Sea Avenger, without the development of an arrestor system, the *Queen Elizabeth* design does not lend itself as a platform on which the X-47B could be used.

Boeing Scan Eagle

Scan Eagle is a lightweight, rail-launched aircraft, recovered via an arrested-net system. It carries stabilised sensors, including a live camera which can provide pictures from over 100 km away. It has an endurance capability of more than twenty hours and can fly at speeds of over 120 kmh. It has been in

operation since 2004 when it was used in the Iraq War. It is in operation in a number of countries including Poland, the Netherlands, Canada and the US.

Comment: Scan Eagle is proving itself a worthy passive asset in the maritime environment. The Royal Navy is already familiar with this technology, having successfully tested it on a Type 23 frigate, HMS *Sutherland*, in February–March 2005 and February–March 2006. The trials established that, in principle, a system like Scan Eagle can usefully be operated from a large vessel of this size in a range of roles, for example, spotting for naval gunfire support.

Schiebel Camcopter S-100

The S-100 is an Austrian-made unmanned aerial vehicle used by the French, German and Swedish navies. It provides only ISTAR capabilities and there are no plans to arm it. It is a very robust aircraft, able to operate in Sea State 5, has a top speed of 220 kmh with an endurance time of up to six hours and a service ceiling of 18,000 ft.

Comment: As an existing marinised platform, the S-100 could easily be added to the *Queen Elizabeth* carriers, allowing the Royal Navy to develop basic UAS capability at sea. It is, however, powered by petrol (which is not normally used on UK ships), although a heavy diesel variant is being procured.

About the Author

Tobias Ellwood was elected Member of Parliament for Bournemouth East in May 2005. Since then, he has held a range of positions including Opposition Whip; Shadow Minister for Culture, Media and Sport; Parliamentary Private Secretary to Defence Secretary Rt Hon Liam Fox; and Parliamentary Private Secretary to the Minister for Europe Rt Hon David Lidington in the Foreign and Commonwealth Office.

Tobias spent five years in the British Army with the Royal Green Jackets and served in Northern Ireland, Cyprus, Kuwait, Germany, Gibraltar and Bosnia. He continues to serve in the Reserve Forces in the Military Stabilisation and Support Group.

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