

The United Kingdom F-35B and Super-size CVF Aircraft Carrier Issues, Decisions and Alternatives

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In 1989 in the Pentagon Navy Annex, Washington DC, I met with the action officer Light Attack (VMA), Deputy Commandant for Aviation, US Marine Corps (USMC) and began a dialogue that was to lead directly to UK participation in what has grown to become the F-35 program. By good fortune, I had been well prepared to initiate discussions. Assigned to the British Embassy in Washington DC, I was a Royal Navy (RN) Commander specialized for procurement and S&T duties (Navy Listed 'Dagger'). A few years previously, I had been the Air Engineer Officer in a Sea Harrier squadron and was also recently experienced in fixed wing aircraft engineering authority technology, support and operational needs and so I was able to present a reasonable pastiche of RN maritime aviation and this provided the essential faculty to be taken seriously by Marine Corps aviation staffs. In late 1989, from a United States (US) perspective, foreign participation in the development of a classified stealthy super-sonic fighter under the US Department of Defense was generally thought to be beset with so many difficulties as to be impracticable. US acceptance of UK participation in a new fighter aircraft program was successful only because of the vision, daring and tenacity of a pivotal small band of US and UK leading proponents who were willing to work outside of the mainstream and spur change; a story to be told on another occasion. The UK became a member of the Common Affordable Lightweight Fighter (CALF) joint US-UK program in 1994. At core of this successful outcome was the common commitment of the USMC and the RN to an advanced short take-off and vertical landing (A/STOVL) aircraft to replace the Harrier. Serendipitously, this basis for a program alliance developed a strong inertia that several times, sustained the program through some uncertain days. Furthermore, after merger with the Joint Advanced Strike Technology (JAST) program in late 1994 the USMC-RN association was instrumental in securing the strong position of the UK in the multi-national F-35 program of today. While, since the inception of the of the joint program, the USMC has maintained a singular and clear vision of the new strike fighter capability and its operational use, the UK-RN approach at higher decision-making levels has suffered bouts of incoherence, lack of imagination and, moreover, it has failed to be persuasive that it has a grip on understanding affordable and effective new age maritime A/STOVL fixed wing (FW) aviation. A most notable example of this appears to be associated with the present UK aircraft carrier and A/STOVL FW aircraft integration design approach which has missed the opportunity to develop a truly revolutionary maritime-air game-changing weapons system.

In the late 1980s Royal Air Force (RAF) staffs made a decision to zero their funding provisions for R&D associated with replacing the vertical/short take-off or landing (V/STOL) Harrier aircraft in the Ministry of Defence (MoD) long term costings (LTCs) financial planning document.

The reason for this decision was that Eurofighter costs were rising and in order to support them, something had to give. Successful introduction of the Eurofighter generation 4.5 combat aircraft had defining importance to the RAF and a planned force structure comprising Eurofighter and the strike Tornado, appeared to be the best approach to secure the Service's operational capability, warfighting effectiveness and future relevance. Unlike the United States Marine Corps (USMC), RAF employment of the Harrier, even though relatively substantial, had come to

exist with a relatively tepid degree of enthusiasm. The operational limitations incurred as a result of having V/STOL capability diminished its strike value to the RAF. The Harrier was able to short take-off and land vertically but it was considered to have range, speed and weapon load limitations. As with the United States Air Force (USAF), the close air support (CAS) mission was considered to be problematic because of potential susceptibility to higher attrition from defensive ground fire (countered later on by emerging precision weapons – becoming a true agent of change). Operations from austere sites (including maritime deployment) and an outstanding ability to sustain high sortie generation rates, so valued by the USMC, merited less when weighed against the preferred and more traditional RAF force basing criteria.

RAF zeroing V/STOL funding in the LTCs was recognized to be a mortal blow to future naval fixed wing (FW) aviation by the sentinels in the Royal Navy (RN) operational requirements (OR) staffs. An A/STOVL successor to Sea Harrier was counted to be the only viable way to replace this aircraft because alone, it would allow next generation FW fighter/attack air to operate from smaller and therefore, affordable carrier platforms; the link between small aircraft carriers, the core mission and affordability was well understood at that time. As the junior aviation service, the RN supported a share of around 25% of Harrier follow-on R&D costs and although this was preserved, without the dominant RAF share the RN had insufficient funding to go it alone. The puzzle at the end of the 1980s for the OR staffs (Navy) was what to do?

Front line Royal Navy (RN) fixed wing (FW) aviation ended once before with the paying-off of the aircraft carrier Ark Royal in 1978. This closing chapter was a consequence of the political decision to cancel the large replacement aircraft carrier CVA-01 in the mid-sixties because it was deemed to be unaffordable and less relevant. However, the RN returned to FW aviation in April 1980 with the Sea Harrier FRS-1 and a smaller aircraft carrier, the so called through-deck cruiser anti-submarine warfare ship, HMS Invincible. If ‘must needs’ austerity rather than any innovative genius was the mother of this new aircraft-ship invention, it matters little. Sailors have never believed the maxim “any port in a storm” to be in the least, pejorative; what counts is that the RN found a path back to FW aviation at sea. History shows that this came not a moment too soon as a nasty type of storm was rising in the South Atlantic abetted by the grossest political miscalculation in Whitehall¹.

Former US Secretary of Defense Don Rumsfeld made a comment about having to go “to war with the army [aircraft] you have, not the army [aircraft] you might want or wish to have at a later time” and he was exactly correct. However, this notion does not provide an absolution for Governments and their military planning staffs to assemble their military capabilities so poorly that the successful outcome of armed conflict is jeopardized due to substandard force mix and limited or flawed or inferior weapons. For sea warfare, there is an obligation to assure that ‘blue water’ maritime forces possess organic air defense cover and the decisions of 1978 and 2006, to dispense with organic RN maritime FW fighter air, should certainly be seen as decisions that exposed the fleet to danger - the most recent of these involved the scrapping of the Sea Harrier.

During WW II, on 27 May of 1941, Sub Lieutenant John Moffatt, flying a Fairey Swordfish, launched the torpedo that stuck and disabled the German Navy Bismark’s steering gear. This was certainly the turning point of a desperate chase and the decisive event that would lead to the *Kriegsmarine* battleship’s sinking. Later in life, Moffatt noted that the weather conditions that the Swordfish operated in that day were “unbelievable”. At launch, the carrier was pitching through 60 feet, the decks were awash and there was ~70 knots of wind over the deck. He took the view that ‘no other ‘planes in the world could have done what the Swordfish did that day’ (we will return to this later). What is not mentioned by Moffatt is that during the chase of the Bismark,

¹ Witness British Foreign Secretary Lord Peter Carrington’s resignation in 1982, taking full responsibility for the failures to anticipate Falkland Islands developments. Ministerial and military resignations are rare in any circumstances and while right to go, Carrington showed great personal honor and principle – and clearly, he took *one for the team!*

the RN aircraft enjoyed local air supremacy unlike the later Swordfish action involving the Channel dash of *Scharnhorst* and *Gneisenau* during Operation Cerberus in February, 1942 (when the superior Luftwaffe Focke Wulf 190 fighter debuted)². On this later occasion, the German air force established local air superiority and the immensely gallant Swordfish attack failed with all aircraft destroyed. The principal take-away from the Bismark and Cerberus operations is that the initial operational air priority was initially to clear the sky over respective targets in order to establish sufficient ascendancy to assure enough impunity to make successful attacks – underwriting the importance of FW fighter aircraft.

The Falkland's conflict provides a similar experience. Anti-Aircraft Artillery (AAA) and Surface to Air Missiles (SAM) from defended enemy positions quickly exposed CAS low flying vulnerabilities (prior to the advent of precision weapons). Low flying avoidance strategies (speed and surprise) in the face of deployed fire control radars were quickly demonstrated to be flawed as the 20 mm cannon-fire strike on the tail of the Sea Harrier piloted by Lt. Cdr. David Morgan bore witness. However, in the air defense role, Sea Harrier FW aircraft successfully mounted Combat Air Patrol (CAP) defenses for task group components; intercepting attacking enemy aircraft or otherwise disrupting their operations. The attrition of surface ships by the successful air attacks of a determined and brave enemy, when fleet air cover was missing, demonstrated quite graphically the importance of organic air defense. Without the presence of 800, 801 and 809 Naval Air Squadron (NAS) Sea Harriers and supporting Air Early Warning (AEW) Sea King HAS 5s of 820 and 826 to provide tactical air superiority at moments of critical importance, retaking the Falklands would not have been possible. Sea Harriers destroyed 20 enemy aircraft. This serves to emphasize that prioritization is needed and that air defense comes first among equals for naval FW aviation which must strive for local air superiority to facilitate strike and other missions at acceptable attrition rates. This does not detract from the importance of other capabilities but follows that the *raison d'être* of maritime FW aviation is the provision of effective fighter aircraft to counter enemy air; even when considering power projection operations. In the absence of effective shore based allied air force air defense assets (e.g. during the German Operation Cerberus), there are only organic maritime fighter aircraft to secure air supremacy, superiority or at least parity in task force operating air space commensurate with achieving operational objectives. In the lead up to the 2006 Sea Harrier decision, it was important for keyed up Navy Staffs to understand and defend the retention of the Sea Harrier because of its importance to fleet air defense (AD).

The present absence of AD RN aircraft in the Fleet is unquestionably, deplorable. It indicates a failure by the Admiralty Board to be persuasive that there is a critical and unambiguous need for fighter capability. It is hard not to conclude that individual senior uniformed naval officers were not up to winning the professional maritime FW aviation argument and it might be imagined, their being bamboozled by First Secretaries and their political masters into accepting militarily dangerous savings measures. Perhaps more obviously, the premature loss of the of Invincible Class carriers, Sea Harriers and Harrier IIs removed the option for the Government to commit maritime aircraft to a number of later coalition missions and so avoid the vexing complexities and delays of off-shore or foreign basing. Although the present Government has only itself to blame because it chose to cut the Harrier-Invincible maritime strike and reconnaissance capability prematurely, damningly it was the Board that evidently lost the military argument.

The RN leans on tradition and it picks out its future leaders at an early stage in their careers and gradually and by increments, it grooms them for high rank. Even the odd Court Martial may not get in the way of a steady ascent for an anointed and rising star. For non-conformists, original thinkers and for late developers who bloom with the acquisition of experience and confidence,

² Kurt Tank's WW II single-engine fighter aircraft described by him as a "cavalry horse" versus the "race horse" Spitfire Mk. V over which its performance was superior in all but turn radius was a 'disruptive technology' and put allied fighters at a distinct air combat disadvantage for nearly a year until the introduction of the improved Spitfire Mk. IX

or those others who are bright but quirky and outside of the mainstream, the chances to catch up are usually slim. An old navy toast celebrates the winnowing effect of a “bloody war and a sickly season” that can shake things up and allow chance to give opportunity to talent that arrives eccentric to the chosen elite – how else might a Major Orde Wingate³ have made the rank Major-General? The RN structure does not groom uncomfortable innovative intellectuals (e.g. such as Von Manstein’s lazy-clever combination)⁴ and is suspicious of those unorthodox but creative people such as US Admiral Hyman Rickover⁵, “Father of the [US] Nuclear Navy” whose single-mindedness was legendary. It seems unimaginable that the RN would elevate an intellectual like Admiral William J. Crowe⁶, USN, for example, as did the United States, because his eclectic and non-traditional past would have appeared inconsistent with usual progression to high command. Few officers on the Admiralty Board have Masters or Doctorate degrees or a strong background in Research, Development, Test and Evaluation (RDT&E), the petri dish of technology discovery and innovative thought. As an institution, the RN has often been comparatively uncomfortable with new technology and innovation and, has preferred traditional approaches (being easier to assess development risk). Naysayers will disagree and cite examples to the contrary which usually have succeeded by evolution or otherwise incrementally but not as a new and revolutionary wave sweeping away all before. There are historic exceptions such as Admiral Beatty, the great RN implementer of change who worked to get ‘coal out and oil in’ to RN ships. At the highest level, Bill Crowe-like free-thinking or Rickover-like obsession can be great instigators of change. However, this can only work if accompanied by a strong, robust and assisting cadre of vocational expertise and operational experience to provide clued-up insight. Evidentially, too frequently during the past fifty years or more, the RN has not produced the leaders able defend maritime air either intellectually or with the necessary vigor. The Navy leadership can only hold itself responsible and should examine its culture for its inability to develop its own modern-day Hugh Trenchard⁷ or Billy Mitchell⁸ for moments when revolution is needed; such men had a passionate appreciation of the importance of aviation for national defense and fought their cause with all of the skill and conviction of a Horatius⁹ at the bridge; they were pugnacious men with the gall to win, whatever the odds. As noted in the foregoing, although the decisions to scrap the Sea Harrier/Harrier fleets were taken politically by a Conservative Government wanting to reduce costs, the responsibility for allowing it to happen falls to the Admiralty Board. Simply, it was they who must take responsibility for not developing the internal expertise to mount an effective defense of the type that had been conducted successfully by the likes of Trenchard and Mitchell in times past.

There has been a long time failure by the RN Aviation Staffs to develop and sell a convincing maritime air doctrine for UK FW air at sea that can provide an unassailable and lasting common wisdom for existential purpose (distinct from *Carrier-Enabled Power Projection doctrine*). The absence of a lasting RN air doctrine has left RN FW aviation somewhat exposed several times since 1956 with Staffs having to invent arguments for continued existence from scratch and on the fly. Contrast this with the USMC whose policy has been consistent and aims for a force in which “all tactical Marine air will be vertical take-off and landing (VTOL) or at least short take-off

³Major-General Orde Charles Wingate DSO (26 February 1903 – 24 March 1944), British Army officer known for creating special military units in Palestine in the 1930s and later, during WW II, in Abyssinia, Sudan and Burma and, is most famous for his creation of the *Chindits*, the airborne deep-penetration troops trained to work behind enemy lines in the Far East campaigns against Japanese occupying forces. Unconventional and quirky taking to wearing an alarm clock around his wrist, eating raw onions and wearing garlic on a string around his neck to ward off mosquitoes, he was highly innovative

⁴Field Marshal Erich von Manstein (24 November 1887 – 9 June 1973), was a prominent WW II *Wehrmacht* commander. He is well known for identifying that “*There are only four types of officer. First, there are the lazy, stupid ones. Leave them alone, they do no harm...Second, there are the hard-working, intelligent ones. They make excellent staff officers, ensuring that every detail is properly considered. Third, there are the hard-working, stupid ones. These people are a menace and must be fired at once. They create irrelevant work for everybody. Finally, there are the intelligent, lazy ones. They are suited for the highest office*”

⁵Promoted Vice Admiral in 1958, Rickover exercised tight control for the following three decades over ships, nuclear technology and associated personnel selection, surviving attempts to retire him by the US Navy staffs until 1982 when the Secretary of the Navy forced his retirement, sweetened by making him a full Admiral

⁶Admiral William J. Crowe, Jr. (January 2, 1925 – October 18, 2007) was US Navy Chairman of the Joint Chiefs of Staff (1985 – 1989) and later US Ambassador to the United Kingdom (1994 – 1997)

⁷Marshal of the RAF, Hugh M. Trenchard (3 February 1873 – 10 February 1956) was instrumental in establishing the RAF, seeing off the predatory aspirations of the Army and Navy and, pressing for the RAF’s own institutions in order to develop airmanship and engender the air spirit; for this, rightly, he has been called the *Father of the Royal Air Force*

⁸William “Billy” Mitchell (December 29, 1879 – February 19, 1936) was a US Army general who is regarded as the father of the U.S. Air Force. In 1925, he was court-martialed for insubordination after accusing Army and Navy leaders of an “almost treasonable administration of the national defense” for investing in battleships instead of aircraft carriers.

⁹From Lord Thomas Babington Macaulay’s famed poem, about a one man prepared to take a stand against insuperable odds and win through

and landing (STOVL) capable". The Marine Corps has strong political advocates, bespoke combat ships, a clear role as special light infantry and, Marine aviation is recognized as second to none in supporting Marines on the ground. Marine generals have managed the Joint Strike Fighter/F-35 program exerting influence on the aircraft development, so assuring that Marine Corps mission needs are well preserved. Contrary to this after 1957, RN aviation has often seemed to wander somewhat aimlessly as various political tides have continued to shift policy direction this way and that. A priority for the Admiralty Board might be to secure development of a convincing doctrinal thesis from its Aviation Staffs. Apropos the USMC aviation, the first listed doctrinal item for the RN is to have Navy pilots flying missions to protect their sailors and their ships; this is the type of union which amongst servicemen, unleashes powerful devotion, conviction and commitment.

In 1991, Sea Harriers flew in Gulf War 1, attacking ground targets and patrolling the no-fly zone. They were later deployed to the 1992-95 conflict in Bosnia as part of NATO's peacekeeping efforts. The aircraft were operated from light carriers in the Gulf and Adriatic, respectively. From 1997, operating alongside the RAF Harrier II GR7 variants in the ground attack role, the Sea Harrier was shown to be less capable and consequently less valuable for the tactical strike mission. With air defense progressively counted as less pressing, the political relevance of the Sea Harrier diminished and with it, the Naval Staffs resolve to defend continued ownership of a fighter weakened. Joint operation from RN carriers served an immediate need but undoubtedly, it undermined the argument for discrete Navy ownership of its carrier borne aircraft. First, Sea Harriers and subsequently, with the Naval Staffs effectively powerless to act, the RAF offered up Harrier IIs as a 2010 savings measure to the Treasury raptors. Ending up with no FW aircraft or aircraft carriers at all, it appears that the RN was out-staffed by the RAF by failing to anticipate an obvious outcome (*déjà vu*). Lest this writer be accused of paranoia by suggesting RAF scheming machinations - no such thing! The Services exist in a state of positive and competitive tension despite chummy intent to operate under joint command structures. By size and understanding of aeronautics, the RAF remains the UK military lead for aviation and the RN Fleet Air Arm (FAA) must defer, respect and learn air-craft from its big-sister service. However, in much the same way that the USMC aviation defends its independence within the USN in a much closer relationship than between RAF and RN, then so must the RN defend its distinct needs and missions. This is for the very good reason that the Navy is the repository of maritime operational understanding. If today the absence of FW FAA assets at sea is palpable evidence that there has been a failure to win the argument then it behooves the Admiralty Board to improve its ability to make its argument. It requires development of an RN cadre of best minds with the intellectual quality and audacity to win the argument within the MoD structure.

Leading up to the 2006 withdrawal decision, the politically numbed RN air culture failed to confute effectively that the relative performance limitations of the Sea Harrier had made it dispensable, so making it more vulnerable to being taken as a savings measure. However, the Sea Harrier's shortcomings, during its operational life as a Navy fighter were arguably never comparatively more than those of the Swordfish as a strike aircraft – and, like John Moffatt's Swordfish, at a pinch, it could recover to a small deck spot in gale force weather. In the early 1990s, the Sea Harrier F/A-2 entered service to replace the FRS-1. Its development was born partly out of lessons learnt from the Falklands War and it was developed for advanced fighter capabilities. The main differences were a new pulse-doppler radar system (the Blue Vixen) and the AIM-120 AMRAAM missile. The Blue Vixen was the first fielded system in the world to be designed specifically for use with the AMRAAM, and at the time was considered one of the most capable radar systems of its kind (it would later form the basis for the development of the Eurofighter's CAPTOR radar system). The Blue Vixen/AMRAAM combination made Sea Harrier a competitive and lethal air defense fighter with the ability to track and engage four separate

targets with AMRAAM simultaneously; to engage beyond visual range (BVR) operating in adverse weather and day-night conditions. At a stroke, the Sea Harrier was lifted to become a much more capable naval fighter with an air-to-air stand-off BVR capability that mitigated some platform shortcomings. Endurance remained less than ideal for CAP and return performance with bring-back payload remained limited (the failure to fund acquisition of the more powerful RR Pegasus 11-61/Mk 107 with its additional 15% high ambient temperature thrust in the 1990s was unfortunate). However, in the F/A-2, the RN possessed an aircraft that provided highly credible fleet air defense¹⁰ with some platform limitations that were offset by the advanced BVR capability. As noted, to have conceded this capability in 2006 remains a horrible calamity for current Fleet air defense. Events in the Middle East may have dominated recent thinking leading to a focus on strike mission priorities but as a reminder of the need for air defense, on August 17, earlier this year, a US P-8A maritime patrol aircraft was intercepted and harassed by a Chinese Shenyang J-11 fighter about 120 nm east of Hainan Island. The US has now deployed additional fighter aircraft on station, perhaps to fly P-8A escort patrols but certainly to provide counter-balance through increased presence. The RN does not operate long range maritime patrol aircraft in the contested South China Sea area, but in parallel scenarios, when it is necessary to test free access to international waters and air space, alone or with allies, fleet assets will remain exposed to harassment or worse until the RN has its own fighter aircraft.

Looking back to the 1970s, with the impending loss of RN FW aviation and anticipating the demise of Ark Royal (1979), Navy thinking was cornered and, when there are few options, the path often becomes more obvious. The energetic and innovative USMC was already showing the way and began to receive its first AV-8A Harriers in 1971 with VMA-513 taking the jets to sea shortly afterwards. RN commitment to a new class of flat-top ship, with the capability to accept short take-off and vertical landing (STOVL) aircraft led to the laying down of Invincible in 1973. A bespoke RN bubble-cockpit fighter version of the Harrier was ordered, this time with the Navy staffs showing commendable guile and persistence in the face of anemic Air Force enthusiasm. What is notable is that the RN path to embrace STOVL and smaller carrier technology was a forced measure. Like a 'shot-gun marriage', it was a forced union because first choice, conventional cat/trap aircraft and carrier were denied politically. For the USMC, the motivation was different since their doctrinal goal was an all-VTOL force and adaptation of Harrier STOVL technology provided the innovative technical lift to get there. As Oliver Cromwell said, "Necessity hath no law" and during the mid-1970s the Navy Staffs brooked no resistance to make it happen – undoubtedly, there were a few uniformed staff officers who visualized the solution and provided the effort – it is a pity that their identities are lost because much is owed to their perspicacity. Forced or unforced, putting STOVL Sea Harriers to sea in the fighter-reconnaissance-strike role in small Invincible Class aircraft carriers ranks as one of the great innovative military adaptations of modern air-sea warfare.

The Sea Harrier-Invincible combination provided a technical change that was militarily transformational and whose potential is well described by Albert Einstein who was reported to have said, "*Technical change is like an axe in the hands of a pathological killer*". If conventional maritime FW aircraft and big aircraft carriers (catapult and arrestor gear equipped) were denied because they were unaffordable, STOVL plus small carrier technologies was the 'game changer' that allowed the RN to return FW operations to sea in 1979. It was the ability to short take-off and land vertically that allowed operation from small deck space and therefore, smaller Invincible Class ships. However, there were other benefits too. For example, The Sea Harrier was a small aircraft and did not require wing-fold and the high sortie generation rate and overall availability allowed fewer aircraft to do more. Technology has moved on and recent

¹⁰ To the House of Commons Defence Committee on Wednesday 24 November 2004, just two years before the RN gave up its Sea Harriers, then 1SL/CNS stated that "there is no doubt the FA2s have got a superb anti air warfare capability"

developments such as precision weaponry, stealth-survivability, systems integration, new sensors and new composite materials allow platform designs to stay relatively small yet still provide exponential improvements in operational capability. The new generation of advanced STOVL (A/STOVL) exploits both original advantages and new technology developments allowing continued use of smaller aircraft carriers. Regrettably, with this new generation of A/STOVL, it is not clear that the Naval Staffs recognized how well these aircraft can harmonize with smaller carriers as a weapons system with immense asymmetric operational value and cost effectiveness; why else dally with F-35C and cat/trap? Although Harrier aviation is over forty years old, it still retains mission effectiveness compared with other aviation (note again the USMC intention to operate Harriers through 2030). Enhancements such as A/STOVL and the incorporation of newer systems and sensor technologies improve some aspects of operational effectiveness by an order of magnitude. The USMC has recognized this, evidenced by maintaining a clear course to acquiring F-35B and 40,000 ton Wasp-Class (LHD), medium carriers. The LHD displacement is larger than light carriers since it has a full dual role amphibious capability. However, the new Italian A/STOVL aircraft carrier, MM Cavour (C550), will carry 12 F-35B and will displace around 30,000 tons and at around 8000 tons more than Invincible Class carriers, is nicely tailored for balanced and more affordable STOVL operations.

Norm Augustine's (US aerospace executive, former Under Secretary of the Army and Chairman of the Defense Science Board) well known law 16 states that defense budgets grow linearly but the costs of new military aircraft grow exponentially and he teased that by the year 2054, the entire US defense budget will be required to purchase just one tactical aircraft. However, remaining somewhat tongue-in-cheek with this, if the one tactical aircraft cost was normalized for capability and, it could be shown to replace everything that was in the air hitherto, then the comparison would be zero sum; logically, neither better nor worse. As development costs rise, the smart warfighter will bear this in mind. A useful comparative metric is the fly-away cost of a tactical aircraft divided by its weight to give an aircraft cost per lb. A 1960s era F-4 Phantom was around \$500 per lb, a 1980s F/A-2 Sea Harrier ~\$2,000 per lb, 2000 F-22 Raptor ~\$3,500 per lb and a 2015 F-35 Lightning ~\$4,500 per lb. The cost increases per pound weight of aircraft are not evidence that the aeronautics industry has become progressively less efficient over the years; rather it is an indication of a phenomenal increase in operational capability as more and improved systems have been squeezed into airframes. 'Bean-counters' bewail high development and acquisition costs and hope to drive them down by pressing for lower design, manufacturing and through-life support costs, et cetera. There are too, factions of military folk who suggest alternative strategies of employing swarms of cheaper lower capability systems. However, there is no turning the clock back with the evolution to technological intensity (save emergence of a new disruptive technology); airframe system density is here to stay. Rather than resist the technology trend, it is important to embrace and exploit it. For example, fewer more capable and smaller aircraft requiring a smaller support foot-print can allow smaller operating bases, smaller ships, fewer aircrew and fewer maintainers. The challenge for the planners is to roll with the technology rather than to buck it. If Augustine kidded about a future where tactical aircraft will be necked down to just one aircraft, this is evidently an impracticable force structure. Nevertheless, smaller carrier air wings that are well dispersed and operating from smaller platforms are a good response to the challenge to optimize the operational usefulness of more capable air assets.

With the UK 65,000 ton displacement super carrier sizing decision, the advantage of advanced F-35B transformational technology is not being fully exploited. Although it is not Norm Augustine's single 2054 aircraft, nevertheless, one fifth generation F-35 aircraft replaces multiple earlier generation aircraft. More warfighting capability is available from fewer fielded aircraft and is compensation for the high F-35B fly-away cost. Not to take advantage of this

disregards the value of a new technology. If an air group of 12 F-35Bs is more effective than two to three squadrons of earlier technology aircraft, a pay-off is the ability to accommodate them in a smaller aircraft carrier platform. The RN super carriers (Carrier Vessel Future (CVF)) are larger than necessary, witness the Italian Navy MM Cavour, that is sized for 12 F-35Bs. Contingency to carry mixed air groups can be militarily attractive but it must be weighed carefully against the question of affordability, total capital value and survivability. A smaller Fleet carrier approach, tailored to 8 to 12 F-35B, is arguably a more harmonized solution and better value for money. The super carrier CVF concept appears to be based on having one carrier at sea with some overlap by the second. A three-carrier solution, at smaller size (e.g. half the size of the CVF) might have assured two aircraft carrier air groups at sea and would increase operational redundancy and increase 'red' force uncertainty.

Why did the later RN leadership not recognize and exploit the design synergy of A/STOVL fifth generation tactical fighter and compact small carrier platform technologies because this was instrumental in late 1980s RN planning and the rationale behind UK pursuit of a partnership in which the USMC was a driving force? Some of the reason might be attributed to the weakening of critical and advanced technology advice available to the RN leadership resulting from the capability free-fall of the advisory UK R&D establishment beginning after 1988. This declined over twenty-five years through Royal Aircraft Establishment (RAE) to Defence Research Agency (DRA) to the rump Defence Science and Technology Laboratory (Dstl). The acquisition decisions to change from the F-35B to the F-35C (USN Cat/Trap variant) and then back to the F-35B, after the high costs of conventional carrier aircraft launch and recovery implementation finally dawned on Staffs and politicians, was as incomprehensible as it was disgraceful. It was procurement practice at its worst and presumably occurred because discriminating technical advice had not been solicited early enough. Evidently, equally awry was the weakness of the operational advice to leadership that supported the premature demise of the Sea Harrier/GR-9 before the inception of the F-35B and which has resulted in gapping fleet air defense with the consequent loss of hard-won maritime FW expertise. Any argument that purports that Harriers had to go because of obsolescence should reflect that it is the USMC intention to operate their Harriers through another sixteen years – besides, as the WW II Swordfish demonstrated, obsolescence is a nuanced notion. The loss of maritime FW practical skills and operational nous over a generation of operators (i.e. 2006/2010-2018+ hiatus) will be very difficult to claw-back and will be costly because experience usually has to be bought through practical lessons. Some common wisdom may never be recovered and regeneration through cooperation with French and US navies will be insufficiently bespoke. These damaging procurement and directorial decisions undermine confidence in whether the highest levels of RN FW leadership are properly engaged with proficient advice, are able to process it and are viscerally willing and able to act upon it. They suggest systemic failings in the executive advisory process and provide little assurance that the canons of innovative technology best practices are being followed.

As did the battleship HMS Vanguard, the massive CVA-01 aircraft carrier, planned as a replacement for the 1970s Ark Royal and cancelled in 1966, belonged to an imperial era. Swept-up by the Harold MacMillan "wind of change" speech¹¹ and burgeoning fervor for de-imperializing withdrawal from East of Suez, such leviathans were considered unnecessary and otherwise unaffordable in the newly emerging global role that Britain anticipated. If, in the run-up to the decision to cancel CVA-01, the Air Staffs promised unrealistic land-based protective air cover, the Navy Staffs also failed to demonstrate with sufficient proofs, the humbug in the RAF

¹¹ British Prime Minister Macmillan's "Wind of Change" speech was a historically important address made on 3 February 1960 to the Parliament of South Africa and signaling the intention to grant independence to most British imperial possessions. In it, Macmillan said: "The wind of change is blowing through this continent. Whether we like it or not, this growth of national consciousness is a political fact".

arguments. Cancellation of CVA-01 (and ironically, it seems likely that one would have been named HMS Queen Elizabeth) led to the development of the 22,000 ton Invincible Class “through-deck cruiser”, so named to avoid any stigma of the great expense that was firmly associated with colossal aircraft carriers. As noted earlier, conception of Invincible ships was less a revolutionary Beatty-like technology innovation, than it was a response to a new political reality. Nevertheless, for all that it was forced by the circumstances of the time, the through-deck cruiser was a clever military finesse and by it, the RN recovered maritime FW aviation. To spoil the fun, following through with the recommendations of the 1981 Defence White Paper, then Secretary of State for Defence, John Knott, decided to sell HMS Invincible to the Australian Navy. The Falklands War reversed the sale decision and allowed the RN to retain ship-borne air defense. Apparently, Knott remains an unreformed opponent of British aircraft carriers and believes that the current new super carriers should be sold off as soon as possible. In recent years Lord Alan West, former First Sea Lord and Chief of Naval Staff (1SL/CNS) and a military adviser to the last Labour Government, has become an open and tireless defender of FAA aviation and of the carriers. Although as 1SL/CNS he accepted a range of severe cuts in the mid-2000s, outside of uniform he has provided strength and advocacy that has appeared to be otherwise missing. Reflecting on both past and present, West wrote to suggest that Knott has never really understood the value of aircraft carriers. Perhaps this is true but in the case of the new super carriers, there is a clear question to be answered...are they indeed the right carriers? John Knott is at liberty to question whether the CVFs (or any carriers at all) are properly suited to the size of the future Royal Navy and to the likely budget available but the definitive opinion should become the business of the 2015 Strategic Defense and Security Review (SDSR 15).

The new RN CVFs are called Queen Elizabeth (R08) and Prince Of Wales (R09) and it is hard to escape the suspicion that they are so named in order to secure a little patriotic devotion and to position anyone trying to cancel them in the rascally disloyal camp. There might be fewer scruples cancelling an Eagle, Furious or Victorious¹²... despite the fact that as names they are much more martially exciting! In 1775, Samuel Johnson stated that “patriotism is the last refuge of the scoundrel” but in this case, it would be ungenerous to grudge the RN a little gamesmanship. Ultimately, a harder form of scrutiny will determine the ships’ futures. The reported cost of the Queen Elizabeth is \$10.4 Bn and financial realism casts doubt on whether commissioning of Prince of Wales will be affordable and will fall a victim of cuts; especially if John Knott’s opinion prevails (despite the Newport Wales announcement¹³). The case for super carriers has been based on power projection and the development of credible UK expeditionary capability. Expeditionary capability is not simple and is nuanced by theater demands. In the Falklands War, protection of assets was of primary importance and so, air defense took precedence. In the UK’s 2011 Libya campaign, strike capability was paramount and a carrier on hand may have reduced the need for RAF aircraft to fly long round trips with multiple air-to-air refuels. Originally planned to carry up to 36 F-35Bs, Queen Elizabeth is a big target, out of proportion to the remainder of the RN force structure and the vulnerability of “too many eggs in one basket” is obvious. This is too much of a concern to be simply swept under a dusty Admiralty carpet as an inconvenient truth. In the mid-1970s, concerned about anti-ship cruise missile threat, then US Secretary of Defense, Don Rumsfeld proposed buying two smaller non-nuclear propelled VSTOL aircraft carriers in place of another Nimitz in order to achieve greater dispersal of tactical maritime aircraft. In the event, Congress did not see it that way (so ignoring President Eisenhower’s warning to guard against the influence of the “military–industrial

¹² Eagle, Victorious and Furious were eminent earlier RN aircraft carriers. Interestingly, after losses in Pacific operations against the Japanese in WW II and with only one fleet carrier, the USS Saratoga, operational, after a US request for carrier reinforcement, in late December 1942, Victorious was loaned to the US Navy. In May 1943, in US service, Victorious, under the code name USS Robin, sailed in company with Saratoga in support of operations against Japanese forces. The allied carriers had a mix of US and British squadrons, with air-cover provided by Robin-Victorious and strike aircraft by Saratoga.

¹³ September 2014 NATO summit meeting, Prime Minister Cameron promises to complete the second CVF

complex” that is wont to serve its own venal purposes) and funded another Nimitz class carrier. Nevertheless, Rumsfeld was thinking ‘out of the box’ in order to address a real concern.

US Navy considerations of big carrier vulnerability in respect of the Nimitz Class are interesting and somewhat contradictory to Rumsfeld’s concern. The Navy says that large size allows for more defenses and greater ability to absorb damage, however, most importantly, it is argued that nuclear propulsion provides a survivability edge. A nuclear carrier is harder to attack because, remaining in open seas, it has the power to maneuver at very high speeds (30+ kts) for weeks on end and consequently, is more difficult to find. Logistic challenges of frequent refueling at sea are minimized other than to support aviation replenishments and domestic needs. The UK CVFs are powered by fossil fuels and do not reap the important nuclear propulsion survivability benefits of Nimitz carriers. Also, although primarily designed to join coalition operations they may be too slow to keep up with a Nimitz carrier strike group (CSG) and the burden of refueling might increase group vulnerability. Lastly there is the simple truth that big ships are big targets and with less speed and the greater logistics burden of fossil fuel use, the UK CVF super carriers undeniably will be more exposed to being located and attacked.

In respect of affordability, the reduction of the current RN fleet frigate force to only 13 ships appears to bear witness to a difficult distortion of RN fleet structure in the current effort to develop and build the two new CVF super carriers and hereafter, to renew the strategic deterrent. Undoubtedly, it will be argued that bigger ships are simply a matter of meeting the cost of more steel but this is at best naive and at worst, disingenuous. A next generation light fleet carrier with displacement increased by 25-30% (above Invincible Class), with more innovative deck area and lifts and carrying an A/STOVL air group of nine to twelve F-35Bs, could provide significant air defense capability, strike and ISR at better value.

There is an idiom (became a favorite of the US political establishment in recent years), “You can put lipstick on a pig [but]... It’s still a pig”. The RN CVFs are very large at 65,000 tons but they are still STOVL carriers albeit enhanced by A/STOVL aircraft. This writer does not suggest these ships are pigs (far from it, they can be significant capabilities, just not the right ones) but highlights that the STOVL super carriers are different from conventional aircraft carriers despite the fact of being more similarly sized. Considering the relative value of the aircraft, the F-35B pays a price in range and weapons payload compared to the F-35C because of the weight and the volume occupied by vertical flight components. The full conventional carrier air package of fixed wing organic air-to-air refuel capability, EW, COD support and AEW¹⁴ are missing in the STOVL RN CVFs. The nuclear propulsion of US carriers is not available to the UK CVFs denying survivability benefits, sustained dash power and reduced logistics burden. All told, the lesser aviation facilities, characteristics and complementary aviation package determine that the RN CVF super carriers come a distant second in capability to, say, a US Nimitz carrier. There is no shame in this because, after all, the US is a “superpower” but better at the outset, to have designed a smaller carrier to exploit the value of A/STOVL and play to these strengths. By building three smaller, innovative, more lethal and cost effective fleet carriers versus one or perhaps two CVFs (depending on the ultimate future of Prince of Wales), the UK might have assured its US ally the prize that it most desires; namely the provision of a quality allied air presence at sea, and available at all times.

While there is a strong sense of the RN CVFs being “decisions taken” and moving forward because of the high level of sunken investment, the pressure cooker of rising cost may yet upset existing plans. At the recent September NATO summit meeting in Newport Wales, alliance members were again urged to raise their defense budgets to 2% GDP and to place

¹⁴ A full conventional US super carrier FW air wing suite will include, for example, S-3B or F/A-18E/F tankers; EA-6B Prowler Electronic Attack (EA); E-2C Hawkeye Air Early Warning (AEW); C-2 Greyhound Carrier Onboard Delivery (COD). The absence of these FW assets in a STOVL aircraft carrier impacts warfighting capability.

especial emphasis on R&D spending and procurement. Perhaps sensing an opportunity to tilt the Scottish Referendum electorate with Rosyth largesse and to impress the US President with the strength of his own and UK proactive resolve, at the end of the summit Prime Minister David Cameron chose cunningly to announce HMS Prince of Wales would be completed and commissioned. This reverses an earlier decision to mothball this carrier and by getting ahead of the SDSR 15, has made the decision 'political' rather than one based on military merits and budget priority. It is not difficult to feel a sense that this is a replay of the F-35B/C/B switch-back decision which proved to be so ill-thought through.

There are some inter-service turf fights to be had during SDSR 15 that may suggest the carrier plans be amended. In a future two-type aircraft fleet of Typhoon and Lightning IIs, the F-35B is not the best aircraft for the RAF. The F-35C or at a pinch the F-35A are better options based on performance capability and cost of operation. Certainly, the RAF might operate some F-35Bs but there is not really good reason to do so – better for the RAF to be all-in with F-35Cs. With the Scottish Referendum over, a simple solution to jobs at the Rosyth Dockyard may be less pressing politics. The reduced number of RN frigates (13) and destroyers (6) is a concern that must cause sleepless nights in the Admiralty with the question of whether the fleet shape is adequate despite existing ship modernization plans. There may too be a suspicion that the ongoing commitment to a strategic deterrent will be weakened by reducing Vanguard class replacement submarines from four to three (SSBN are self-evidently invaluable to global stability, Britain's position on the Security Council and to Britain's ability to exert mature influence on the world's super-powers - despite the former First Minister of Scotland's apparent views to the contrary). Caught between a rock and a hard place, with the massive investment made in the CVF super carriers, it might be argued, to coin Margaret Thatcher's well known phrase, "there is no alternative"; except to continue as planned. However, there is always an alternative and a third way too but it comes down to how much pain is tolerable by accepting it. It is inconceivable that the Treasury Mandarins have not already considered alternatives, in camera, to cut the CVFs and sell them off; sniff the insight of John Knott in the matter. There is certainly a precedent for this such as when the recommendations of the 1981 Defence White Paper popped out with the surprise of a jack-in-a-box and, Invincible and Hermes were up for sale. The RN must hope that true best value and military rectitude win out over political expediency during SDSR 15.

After 1956, there was a sea-change in the US and UK relationship. The lesson for Britain from the bruising Suez Crisis episode¹⁵ and its progressive imperial divestment was that it had become a middle ranking power, albeit one with a global perspective and sufficient remaining stock to act alone in the national interest when necessary. Peripheral in the development of the European Economic Community (EEC) but benefitting from the warmth of the Kennedy-MacMillan relationship and development of an independent nuclear deterrent, in the niche of East-West power the UK eased into a real *special relationship* with the US. Leaving the Foster Dulles years behind and not based on just cultural niceties, the new relationship developed on the basis of common national self-interests with Britain leveraging a higher global status through its close relationship to the US superpower. In the unwritten deal, the UK invariably provides stalwart public support to US foreign policy and acts as an empathetic bridge to the European community nations. As in all relationships, it is imperfect such as when the Wilson Labour Government refused to enter the Vietnam conflict, or when the US invaded Grenada or with differences over sympathies regarding the Northern Ireland terrorism and so on. Perhaps too, Margaret Thatcher's tenure was characterized by a degree of greater independence and when

¹⁵ At a low point in US-UK relations, only a little less bad than in July 1776, the US brought financial pressure on the UK to end the invasion of Suez. With the pound weakening, the British Government sought immediate assistance from the IMF, but it was denied by the United States. The President instructed preparations to sell part of the US's Sterling Bond holdings and supported an oil embargo on Britain and France. Faced with the ramifications of devaluation, unable to pay to import sufficient food and oil to sustain the population, Britain caved in and moved to ceasefire and then quit Suez. Humbled but in the best traditions of the playing fields at Rugby, hard feelings for the beating by Uncle Sam were put aside; after all, free world attention had been deflected too long from the concurrent brutal Soviet suppression of the 1956 Hungarian revolt.

US action was counter to UK interests, she sought to establish separation, if respectfully, with her pal in the White House. However, overall, by supporting the US politically and materially with soldiers, ships and aircraft, in theory a British perspective is enabled from the inside and is expected to be more effectively influential in moderating US reflexive unilateral tendencies. From a US Executive point of view, the difficulties and sometimes stigma of unilateral action are mitigated when a willing ally is ready to share an international load. The benefits to both sides have persisted in these forms since the beginning of the 1960s.

In US President G W. Bush's war in Iraq, it was natural for British Prime Minister Tony Blair to follow the *special relationship* principle and publically support the US lead during the build up to war in which he eked out a role to carry the primary burden of diplomacy in the hope of securing influence on the US agenda. (Sadly, Mr. Blair failed to appreciate that his congenial relationship and sharing the use of Colgate toothpaste with the President was trumped by the influence of the administration neoconservative¹⁶ ideologues and various Congressional factions and so, actual UK influence on US foreign policy proved weak). To be effective in the *special relationship* alliance, an essential component for the UK has been the need to possess material capability in the form of weaponry that can be integrated albeit with asymmetric effectiveness into the dominant US military effort. For the Iraqi invasion, a wide spectrum of UK air/land/sea capability was appropriate and contrasts with the 2011 NATO intervention into Libya where more singularly, air power was important. The last Harrier flight from a UK carrier (Ark Royal) took place on November 24, 2010 and with its passing, UK carrier borne air capability ended. From a US administration viewpoint, this was a serious loss of the ability of the UK to contribute militarily and it obviously weakened an important aspect of the premise on which the *special relationship* is valued. In a BBC Radio 4 Today program interview in January 2014, former US Secretary of Defense, Robert Gates, suggested that Britain's reductions in defense spending had undermined full-spectrum capabilities and therefore, the ability to be a fully effective partner to the US. Gates singled out cuts to the Royal Navy as particularly damaging and he noted pointedly that the UK no longer had aircraft carriers. Drawing attention to the loss of the Harrier and Invincible Class carriers, Gates was stating the obvious and his exasperation was clear. He might have drawn on the words of the anglophile, President Dwight Eisenhower to his aide, Emmett John Hughes during the unhappy Suez crisis, "Of course there's nobody in a war I'd rather have fighting alongside me than the Brits...But in this thing! My God!" Alan West took time out to increase ministerial discomfort saying the government had underestimated the impact of the cuts to the US relationship and had failed to factor it in when deciding on the cuts. The November 2011, Ministry of Defence (MoD) sale of 72 Harrier IIs and spare parts to the USMC for a knockdown \$180M failed to sweeten the dire loss of capability to alliance operations and has probably caused weakening in the US-UK balance sheet relationship as suggested by West (Prime Minister Cameron's undertaking during his Newport, Wales, speech to complete the second CVF super carrier likely had in mind to redress damage). The take-away is that Britain's three through-deck cruiser aircraft carriers with their Sea Harrier and/or GR-7/9 STOVL air groups provided a credible and flexible allied capability which was valued by the US. The increased size the UK CVF carrier brings little additional quantitative advantage to the US with its own massive fleet of 11 (/10) big deck carrier groups but the current UK capability hiatus hurts.

As an aside, the irony with Gate's statements concerning the UK giving up its RN Harrier capability is that the only remaining British Harrier aircraft currently flying is Sea Harrier XZ 439 and is being flown by an American. It is owned by Art Nalls, a former USMC officer and AV-8 pilot and it performs during the annual air show display season in the USA. Nalls observes that

¹⁶ Included Dick Cheney, Donald Rumsfeld, Paul Wolfowitz, John Bolton, Elliott Abrams, Richard Perle, and Paul Bremer – and the neocon theorist Jean Kirkpatrick, a US Ambassador to the UN, a strong supporter of President General Leopoldo Galtieri and his Argentine military dictatorship, she advocated non pro-British policy following the 1982 invasion of the Falkland Islands

his Sea Harrier is a “fighter aircraft designed to shoot down enemy aircraft...with a 50,000 foot-per-minute climb rate, it is much faster” than AV-8Bs that were designed for air-to-ground and close air support. The present UK Naval Staffs might be disposed to remember this fighter emphasis that was evidently in the minds of their 1970s predecessors and is remembered by a former Marine Corps pilot as he thrills American crowds with his Sea Harrier.

If the Queen Elizabeth CVF enters service in 2020 with F-35B A/STOVL aircraft, it will be Britain's largest-ever ship. Designed to carry a surge air group of up to 36 F-35Bs, alone it will have more strike power than many countries' total air forces. However, both directly and indirectly its large size arguably makes it vulnerable and puts it at variance with a more advanced and innovative approach. Drawing on the issues raised earlier in the article, some of the critical points are as follows:

- a. **Affordability** - High CVF unit procurement costs appear to be sustained by cutting numbers of smaller RN ships, delaying other programs and perhaps to the detriment of the other Services' needs. Essentially, the defense budget is a zero sum game. The UK long-term equipment procurement plan budget (2013-2023) was reported to be set at around \$103bn¹⁷. Completion of Prince of Wales might be as much as an additional \$13bn and will constitute a significant burden.
- b. **Vulnerability** – A large capital ship is a monolithic platform and is vulnerable to missiles and other anti-ship devices and, as part of a carrier strike group (CSG) it is likely to need 4-5 surface escorts. Recognizing that F-35B is a fifth generation aircraft with much increased capability, smaller air groups dispersed to smaller carriers (possibly 3 small carriers <30K tons displacement class) can be militarily effective but less vulnerable. Dispersal provides greater CSG redundancy with the combat attrition of one ship built into operational planning.
- c. **Strategic Partnership** – The UK super carriers do not by their size alone, improve the US-UK the *special relationship* – it was the politically ordered premature retirement of Invincible Class carriers and their aircraft that caused obvious credibility damage. Most recently for example, operations allied to the US in the eastern Mediterranean against ISIS/ISL, launched from RN carriers, were not an option.
- d. **Performance** – The size of the UK CVF argues for nuclear propulsion which would have raised maximum sustained speed to above 30 knots and perhaps to approach closer to the limiting hull speed¹⁸ of around 38 knots, extended range up to ‘very far’ and lowered the logistics burden and importantly, improved survivability. The maximum speed of the UK CVFs is publically reported at greater than 25 knots but may be less or close to the 31.5 knots of the WW II carrier, HMS Furious, that was launched in 1916!
- e. **Survivability** – With a surge air wing of 36 aircraft in a ship crewed by around the same number (~650) as Invincible Class carriers, the argument of scale appears to show the commercial value for money. Design to low cost and commercial is all very well but the CVFs are warships and without adequate manning in such large vessels, despite improved automation, their damage-control and firefighting capabilities and overall survivability will likely be weakened – this is a primary concern and it is not clear that key survivability lessons from the Falklands war are well enough incorporated.
- f. **Advanced Technology Leverage** – The CVF super carriers appear more evolutionary than revolutionary and have not exploited the advantage of transformational A/STOVL technology to facilitate reduced carrier platform size – the UK has lost an opportunity to lead more aggressively with innovative A/STOVL carrier platform development although the design will take some credit for the development of the mechanized weapon

¹⁷ NAO *Equipment Plan 2013 to 2023*, HC 816 Session 2013-14, dated 13 February 2014

¹⁸ The practical speed limit in knots for a displacement-type hull is approximately equal to the square-root of the hull length at the waterline (LWL) times 1.34

handling system (HMWHS) which is certainly in step with the future although it probably lags the more Advanced Gun System (AGS) of the US Zumwalt Class destroyer (DDG-1000) with its fully automated ammunition supply, system operation and stealth.

- g. **F-35B** – Is the best choice of aircraft for RN maritime operations if it is suitably integrated for maritime operation. It is the wrong aircraft for RAF in a future mixed Typhoon-Lightning II fleet. The weight, complexity and cost of VTOL systems reduce performance significantly. The UK will need to address the F-35-type buy and will likely split the procurement to mixed F-35B/C procurement. Fewer numbers of the F-35B will reduce the need for two super-size CVFs. It is important that SDSR 15 addresses this issue since it provides one of the few ways to untie the defense equipment Gordian knot.
- h. **RN Aircraft Mission** – The F-35B design mission is tactical strike, as the cockpit canopy shape bears witness (arguably more akin to Sukhoi Su-34 than the F-16/F-22 bubbles although somewhat compensated with the well reported electro-optical Distributed Aperture System (DAS)). Also developed (second to F-22 Raptor) for reconnaissance and air defense, the RN F-35Bs, as with the Sea Harrier, will need investment to be consolidated as an effective maritime air defense fighter capability. Maritime air defense has been contended by this writer to set the RN need apart from the RAF by providing unique FAA definition and remains the strongest argument for organic naval FW aviation. The optics of the intention by the RN to name their Lightning II squadron 809 Naval Air Squadron (NAS) confirms subtly a message that fleet air defense is of lessor importance than strike since the most recent pre-Sea Harrier 809 squadron aircraft was the Blackburn/Hawker Siddeley Buccaneer. In 2013 Admiral Zambellas took any doubt away when announcing the name and saying that it had been chosen to establish a “link with... embarked carrier strike”. Perhaps 892 NAS¹⁹ would have redressed and better balanced the RAF choice of their famous bomber 617 “Dambuster” name?
- i. **Must Wins** – There have been too many RN leadership failures with maritime aviation during the past fifty-seven years and this has been detrimental to the coherence of effective national defense. The “spirit of collaboration” is all very well but there will always be competitive tension between the Services; the RAF will argue aircraft first and so long as the RN lead with colossal ships and not the aircraft, they will come second in the great intra-MoD air game. It is important to win the inter-Service argument and to take an unassailable logic into the political arena – essentially, maritime FW aviation must be presented as being discrete, unique and defensively essential. While the present 1SL/CNS has an aviation background – this does not assure creative and critical aviation thinking, FW prescience and Trenchard/Mitchell-like obduracy (with no offense or mutiny intended). *Leonardo da Vinci* supposedly said, “Knowing is not enough; we must apply. Being willing is not enough; we must do”. RN leadership ought to identify the critical needs, be a master of the detail and must win [do] its argument more consistently. The Naval Staffs must also develop an understanding of Air Force FW air to be able to support their argument – send middle ranking officers, not to read for Masters in business studies but in strategic studies writing their thesis on next generation air power, fighter air over the sea and disruptive tactics, for example. If 1SL/CNS is in any doubt that the message is not getting through, simply turn to the current Wikipedia Lockheed Martin F-35 Lightning II page which lists primary users as USAF, USMC, USN and...RAF; there is not a reference to the RN! Early in the Joint Advanced Strike Technology (JAST) days this writer was indefatigable in efforts to blaze UK participation with an RN stamp because this was the route to attention, influence and respect of national interests in a US-managed program. Times have changed and

¹⁹ 892 Naval Air Squadron (892 NAS) was a RN FAA carrier-based fighter squadron that was formed in 1943, flying US Grumman Martlets; later fighter aircraft included the de Havilland Sea Venom, the Sea Vixen and the McDonnell Douglas Phantom FG.1

perhaps the church is broader but like Dutch *total football* from the late 60s and early 70s, there must be full engagement and, no detail can be too small for sharper RN top leadership... and why not make a start by getting Wikipedia changed?

- j. **Integrated Weapon System Design** – Creative systems integration exploits the synergies between the discrete parts. The transformational value of A/STOVL fifth generation aircraft technology should be the primary influence on ship platform design (just as 19-20th century battleships were designed around their massive guns). Any failure to develop a highly innovative platform design that is cleverly integrated with the aircraft misses a moment of technical opportunity. A principal value is the ability to down-size but also, to do more at smaller size. The F-35B aircraft is larger than the Harrier (i.e. twice empty weight) but its technology density is much, much higher. Compared with another fifth generation aircraft, the F-22 Raptor, it has more than four times the lines of software code (i.e. 8.6 million)! Since fewer aircraft will do more, the air wing can be smaller allowing the carrier platform design to be smaller. Observing that the F-35B has a more limited range than the F-35C, a smaller RN carrier should be designed for high speed, endurance and lowered signatures to enable operations in which the aircraft carrier can dash-maneuver to insertion and recovery points and thereby extend strike range. The type of aircraft carrier that emerges is a new concept in maritime aviation whose size, speed and survivability. With its compact size and organic air-wing it might operate safely in harm's way with fewer ship escorts.
- k. **Coalition Operations** - Speaking to a Washington DC audience in the Center for Strategic and International Studies on July 30, 2014, perhaps to counter the angst expressed by Robert Gates earlier in the year, current 1SL/CNS Admiral Sir George Zambellas was reported to have explained that the new UK strike carriers “are designed primarily to join coalition operations²⁰.” However, without catapult and arrestor gear the CVF super carriers will offer no deck interoperability with US Navy and French Aéronavale FW aircraft. Furthermore, this dominant goal of coalition interchangeability with US aircraft carriers has led to UK carrier supersizing and growth of the air wing size (36 F-35B) which has detracted from a more suited UK design approach that better exploits new A/STOVL technologies. As a tortoise, it makes no sense to try to run like a hare – but the tortoise has other strengths, so design to them!²¹ And they may integrate surprisingly well better serving both national and coalition operational needs.
- l. **Politics** – The Navy leadership has a full share of responsibility for choosing super-size aircraft carriers. However, the decision was at the instigation of a Labour Government concerned about jobs and evolving a new foreign policy involving an ideology of spreading democracy, improving human rights and working through the international community, using military force if necessary, to effect change in the most desperate and despotic global dictatorships. The concept of a powerful multi-mission strike platform seemed to fit the need to allow more global proactivity. The replacement of Invincible Class carriers was approved in 1998 and after the December 2003 Defence White Paper, a decision was taken to replace them with two large carriers. The superseding Conservative Government inherited the decisions but did not challenge them although it contributed a measure of ineptitude with the witless F-35B-C-B switch episode
- m. **Strike Carrier** – Undoubtedly, the concept has value even if not technically bespoke to actual Navy needs. The ability to operate Merlin, CH-47, AH-64 and FW (non-cat/trap)

²⁰ Giving evidence to the House of Commons Defence Committee, 24 November 2004, then 1SL/CNS Admiral West explained that interoperability with the US Navy was as much a deciding factor of the size of the carriers as the firepower of the carrier's air wing. He noted that having talked to the US Chief of Naval Operations (CNO), CNO was “very keen for us [UK] to get these [super carriers] because he sees us slotting in with his carrier groups. He really wants us to have these [super carriers], but he wants us to have the same sort of clout as one of their [US] carriers which is this figure at 36 [F-35B]. He would find that very useful, and really we would mix and match with that”.

²¹ Taken from Aesop's fable of the 'The Tortoise and the Hare'

from the CVF super carrier deck and to execute military operations without dependency on foreign airfields provides remotely deployed military clout and gives the Government improved global leverage. Arguably, having a Jack-of-all-trades ship is a cheaper solution but pays a price in point effectiveness. This writer is certainly not against flexibility but believes that specialist demands and maintenance of operational currency mitigate strongly for separate fleet carriers (AD/ASW) and LPH, LHD or LPD (Amphibious Operations)

- n. **Inertia** - The decision to build 65,000 ton aircraft carriers was not the present 1SL/CNS's; he inherited it as did his predecessor. He does not bear the principal blame for the political mess associated with the F-35B-C-B switches however; his office is where the "buck stops" and credibility is damaged. The inertia to press on with the two CVF is immense. Any deviation or internal RN questioning would be seen at best as acts of folly and at worst, disloyalty – in a storm, all hands must man the pumps and put aside differences. The ability of the RN itself to reform the super carrier decision really does not exist. The only mechanism on the horizon with the power to change the present course is likely the SDSR 15. Attacks from the other Services, similarly under the cosh of cost savings measures, will not be held back by any scruples associated with earlier agreements. Alternative assumptions can be expected, like a flood, to swamp any "spirit of collaboration" in the fight for a better share of the financial pie.
- o. **No Alternative** - The elder von Moltke²² said famously that "No operation extends with any certainty beyond the first encounter... with the enemy." It would be wise for the RN to contemplate Plans B – von Moltke's hypothesis was that given the uncertainty of first contact, if you prepare by staffing for all eventualities, you will most likely have developed the contingency to respond appropriately. If, despite the Newport Wales announcement, the second CVF is left incomplete, moth-balled or sold off and if, and very sensibly, the F-35 buy is split between B and Cs, the strike super carrier concept is hollowed-out. Anticipating the worst, development of a sounder vision that puts maritime FW air more in league with present and future alternatives might be prudent preparation.

This article has been written to question and does not pull punches in respect of suggesting where responsibility lies. It has not been written to be destructive, perverse or intentionally offensive. It has considered the role and importance of maritime organic FW aviation, the nature of historic periodic losses of RN aircraft carriers, failures in leadership prescience, the impact of the present gapped RN FW capability, the misunderstanding of A/STOVL capability, the failure to exploit the game-changing technology in smaller more affordable aircraft carriers and, it has critiqued some problems associated with the Queen Elizabeth Class super carrier decision. For those in high office, well, I have laid fault at their doors as sensibly it must fall there although I see little merit in any personalization since I have little doubt that people were motivated with integrity even though probably ill informed, distracted, domain-challenged, wrong-minded or not well-enough up for the fight. Much as many people will wish, the issue of super carriers for the RN is not water under the bridge and it should not be. There are evidently a number of unresolved issues most notably affordability, lethality effectiveness, the F-35B/C question, the need for new realism and of course, politics. There are several possible outcomes. They range from playing the hand as it is presently dealt to seeking a more revolutionary, if painful approach causing more turbulence in the short term. What cannot be avoided is the recognition that following the demise of the Sea Harrier fleet and the Invincible Class carriers, the RN is without fleet organic FW air defense, reconnaissance and strike and is unquestionably badly exposed for blue and remote brown water operations. That this was allowed to happen despite the known

²² Field Marshal Helmuth Karl Bernhard Graf von Moltke (26 October 1800 - 24 April 1891) was the chief of staff of the Prussian Army for thirty years, he is regarded as a pre-eminent 19th century military strategist. He innovated new approaches to directing armies in the field. Referred to as *Moltke the Elder* to distinguish him from his nephew Helmuth von Moltke, who commanded the German Army at the outbreak of World War I

RN maritime warfare experience is almost beyond belief but was perhaps well measured by the depth of US dismay voiced by the former US Secretary of Defense during his BBC interview.

Looking forward, what can be done? Machiavelli²³ wrote, "It ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things." The RN leadership is too committed to the plan for two CVF and a suite of F-35B aircraft to reconsider and to propose a more innovative way forward. Any weakening in resolve will be felt as being akin to opening a Pandora's Box after which everything might unravel. However, if the SDSR 15 is not too politicized, it may arrive with the impact of an out-of-control juggernaut and disrupt the present status. National interests, military roles and strategies, affordability and best value will be re-assessed. The competing interests of the other Services, doubts concerning the suitability of current choices and political-budgetary imperatives will likely provide cause to look afresh at earlier decisions. The John Knott view may yet secure traction. SDSR 15 may become the agent of change to trigger an alternative way forward.

Another of Augustine's laws, number six, paves the way to an aggressive Navy Staff position: "A hungry dog hunts best. A hungrier dog hunts even better". Having lost Harrier, there should be no lack of appetite for the fight. Wishfully, this writer would hope to see a return to a smaller carrier and smaller air group approach and to the prospect of a more balanced fleet in which the FAA leads the world in an imaginative and operationally advanced maritime F-35B A/STOVL aircraft and ship platform weapon system. To this end, the following are suggested:

- If the decisions to switch F-35B to C and back to B (with the prospect of a further split buy arising during SDSR 15), to prematurely give up Harrier aircraft and Invincible Class carriers and to procure two super-size CVFs were not smart, there is reason to conduct an inquiry or meaningful review to understand why and what has happened. If there has been dysfunction at leadership levels and if there is to be confidence that defense planning is being properly conducted with value for money, lessons must be learned with more professionalism and accountability associated with future decisions.
- The Admiralty Board to consider again the existential question of maritime aviation remembering that without exception, the first rule of carrier aviation is "*Protect the Carrier*". This should lead to the development of a broad vision for all maritime aviation and that in particular, incorporates a defensible rationale for FW air; it having proved so vulnerable to being cut in recent pastimes. It must speak to the unchanging value added part of maritime FW capability and must be sufficiently persuasive to become lasting doctrine and common wisdom. FW air defense has been an unchanging need since aircraft first went to sea and is certainly candidate for blue ribbon status today (despite attempts like doomsayer and former Secretary of State for Defence Duncan Sandys²⁴).
- The RN FW aviation mission remains multi-role. It is fighter, reconnaissance and strike; however, 'fighter' should be first mission priority among equals and fleet air defense developed as a capability that has sufficient military effectiveness whether for independent or coalition operations. Historically, promissory air force provided fleet air defense for blue or remote brown-water operations has proven uncertain and whether well intentioned or not, it must not be allowed to stalk future considerations. Lastly, the RN should remember that the USMC envisage the F-35B to be tactical air and not

²³ Niccolò Machiavelli...In the "The Prince", he recognized that entire noble families might have to be exterminated to flush away ingrained institutional impedance and to allow change to be embraced and sustained – in essence, clearing the way for new management in today's terms requires early retirements and firings to make way for a transforming management cadre able to make new starts

²⁴ In his 1957 White Paper on Defence, then UK Secretary of State for Defence, Duncan Sandys, suggested that guided missiles had made manned combat air obsolete – history has shown this opinion to be premature and likely wrong although it is about to be tested again with the onslaught of ubiquitous remotely piloted vehicles

strategic strike and so, UK F-35B stand-off capability expectation should be held in sensible check.

- Coalition operations have challenges of their own because national weapon systems are different, usually leading to sub-optimal standards of interoperability. Starting from a point of nearly identical operating systems, with time national systems change linearly but comparatively, with other coalition systems, they change exponentially. Maintaining lavish coalition commonality comes at a high price and future RN maritime FW aviation should not become a slave to it.
- As discussed above, the RN should remain committed to the F-35B but the total procurement should be split, with the RAF buying F-35C recognizing better land based performance of the big-wing variant. Initially, two F-35B squadrons might be established with one deployable and the second a headquarters unit. F-35B squadrons might be located not at Marham but at RNAS Yeovilton with this base becoming established as a *Center of Excellence* for maritime A/STOVL operations, development and sustainment of specialist expertise. Virtual facilities (interware) would enable Yeovilton to act as an effective satellite to Design Authority, RAF and other support organizations. FW maritime aviation is a domain expertise in its own right and if not protected, is quickly perishable. Maintaining currency in three roles, deck launch and landing and day-night capability is a massive continuation training burden. A slow recovery from the Harrier-Invincible Class decisions will probably prove this to any doubters. Rickover, Trenchard or Mitchell-like focus is required to explain and defend a strategy that is developed to re-build and subsequently protect this expertise in future times. There may be a suggestion that this is parochial and thoroughly counter to an anticipated future of shared assets and combined operations. Perhaps, but failing this, F-35 integration with nascent Eurofighter Typhoon strike air group imperatives will gradually dominate the importance of integration with aircraft carriers and maritime operations will not achieve or maintain the level of excellence that is necessary for seaborne operational effectiveness (You don't believe this? Go ask US Marine Corps air). The RN and RAF are clearly not enemies but there is a continuing competitive tension that demands mutual respect and the allowance for each to operate with a measure of operational independence.
- The 36-aircraft surge strike wing should be abandoned. RN squadrons might operate eight to twelve aircraft and an initial F-35B buy of ~36 aircraft is anticipated although full through-life attrition will be more.
- The ambitious power projection strike carrier concept to be abandoned on the basis of vulnerability weaknesses. However, with a priority to recover FW air capability, Queen Elizabeth to be commissioned into service. A new and revolutionary concept of fleet carrier to be developed at an accelerated pace and harmonized with A/STOVL F-35B and other VTOL assets. Three new build advanced multi-air capability fast fleet light (aircraft) carriers (AMFFLC) would be procured in phases and Queen Elizabeth sold off in the mid/late-2020s. Prince of Wales to be stopped as soon as possible or post SDRS 15 to save political face.
- The three new AMFFLC light fleet carriers would be designed to exploit A/STOVL aircraft capability and drive down size. At less than half the displacement of super carriers they might be designed for very high speed, fast reaction, long endurance, high survivability, compactness, reduced logistics dependency, deployability, capable of operating with fewer escorts and secondary/tertiary mission utility. To achieve transformational operational capability, nuclear propulsion is favored over gas turbine-diesel integrated electric propulsion (IEP) system (or other CODOG). This single aspect would bring especial new lethality to operational effectiveness but is certainly a decision requiring boldness and dealing with the challenging cost and basing implications. Likely

the Board would need its own latter-day Rickover to fight the case. Other innovative systems might also be included such as the employment of assisted unmanned AEW capability. AMFFLC, provides a path to a revolutionary and disruptive multi-role maritime air warfighting capability that is effective against emerging threats. It requires the employment of innovative approaches and must be immune from making the type of uninformed decision that allowed the RN to toy with the use of the US-developed Electromagnetic Aircraft Launch System (EMALS). It would put the UK in the lead of world maritime A/STOVL technology.

- In the US the F-35, like an acquisition maelstrom, has sucked in resources so completely that it has left less than 'thin pickings' for any other strike-fighter approach even though the USN and USAF continue to muse more bespoke options. Despite having superior performance to the F-35B, the F-35C is not a strategic strike aircraft such as a B-2 or B-1B. The USMC sees its F-35B as tactical air. The F-15E Strike Eagle and USN F-18E Super Hornet with their re-assuring twin engine configuration have survivability benefits and are good value for money. Although the single versus two-engine argument was settled in JAST during the mid-nineties and the decision served to solve a USN acquisition conundrum, it still left the more cautious folk wistful over the absence of mutual engine backup. As the RAF considers the challenges of Syria-Iraq type long range strike operations, it too may take comfort that Tornado has two engines like the 15E and 18E. Clearly, the RAF has some critical thinking to do as it weighs the positives and negatives of lower signature, external/internal weapons carriage and two engine redundancy
- Allowing cost to drive weapon system capability and not those threats that must be countered militarily is a dangerous path that can lead to being out-classed by enemy systems. Affordability is unquestionably vital and has to be part of any modern system design approach. However, there is the common sense that says that a system that costs very little to field but also possesses little lethality is actually worth nothing to the warfighter. The CVFs are the product of a massive meat-grinding acquisition system lacking the sensitivity to pursue the most revolutionary, innovative and synergistic technical approaches. Adherence to artificial Key User Requirements, industrial share issues and the huffing and puffing of Parliamentary Defence Committee oversight on matters technical transfer and so on have served to dull the appetite for truly transformational approaches that are ahead of their time. This is something that the UK has been good at doing in the past sometimes but has lost its way with the sizing issue of the CVF super carriers. Examples such as the 2005 RAND Corporation report '*Options for Reducing Costs in the United Kingdom's Future Aircraft Carrier (CVF) Programme*'²⁵ concerning detail ship outfitting choices illustrate a "penny wise"²⁶ catch-up mentality to acquisition versus a grander and smarter strategy that exploits a synergistic carrier and A/STOVL techno-operational fit. The RN desperately needs its own Rickover to point the way!

At various points, this article has contrasted the clear sense of doctrinal purpose shown by the USMC for their F-35B within the VTOL Marine force structure with the often perplexing path taken by the RN which has stayed subservient to the flawed will of its political masters. If the RN is to do better, there are a number of lessons that should be learned to prevent a near future repeat of the more obvious mistakes – UK Governments of all molds and the Services all share in the responsibility for the present situation. As things stand, this writer believes that the RN has a choice of whether to brazen it out through the SDSR 15 or to begin to turn the page, to

²⁵ The RAND report examined both procurement and construction costs, and in-service costs but not whether the conceptual approach of super carrier size and A/STOVL provides superior design harmony.

²⁶ From the idiom, "penny wise and pound foolish", indicating prudence and thriftiness with small amounts but wasteful and spendthrift with large amounts...

consider alternative paths, to recover operational maritime aviation and to commit to a future that is technologically more advanced, innovative and transformative for FW maritime air capability.

There is a general rule of warfare that says the combatant that develops the best technology and fields it first and in operationally significant numbers will usually win subject to proficient deployment and utilization (e.g. introduction of the earlier mentioned FW 190 fighter aircraft). This is the fundamental reason why modern militaries must invest in advanced technologies and race to develop new systems that provide winning combat edge. Ignore this by allowing obsolescence creep, inferior technology acquisition or least cost shortcuts to fashion weapon system effectiveness and militaries are exposed to being prejudicially outclassed when engaged by the enemy. Low manning numbers (compromised damage control capability), limited speed, logistics burden, limited survivability and very large size appear to be CVF design choices that the RN may come to rue. Changing CVF decisions at this stage would be difficult but there may be near term offsets such as, for Government, financial savings associated with stopping Prince of Wales and for the RAF, a concession to support a change to F-35Cs. Optimization of the A/STOVL F-35B capability is very strongly dependent on the carrier basing approach and small, very fast, long endurance, compact, distributed air wings and survivable are design qualities to be preferred. But to accept this argument, there must be a sea change in thinking in which the importance of FW maritime air is consolidated. A number of important issues and alternative approaches have been raised in the foregoing but first, the Admiralty Board should address the *reason for existence* question with regard to the FAA and in particular FW capability. Taking a lead from the words of Hugh Trenchard in 1919 when defending the need for distinct RAF institutions, there is a need for the Board to develop FAA FW maritime “airmanship and [to] engender the [maritime] *air spirit*” because in this matter their effort has appeared woeful judged by results these last two decades or more. There is a desperate need for an RN FW doctrine that transcends changing political persuasions (à la USMC aviation). A starting point is that the Navy should develop a cadre of informed, enthused and aggressive aviation leadership that will understand and embrace technology and change. They will fight for and they will win for FW naval air, brave and transformational new approaches beginning with smaller bespoke carrier designs. This writer believes that it is in the UK national interest as well as the Navy’s. Time is short and as Abraham Lincoln once said, “The dogmas of the quiet past are inadequate to the stormy present”. There should be rougher times ahead.