Written Evidence submitted by Lockheed Martin UK

1. Lockheed Martin is the fifth largest supplier by revenue to the Ministry of Defence (MoD) with over 80 years of heritage in the UK. It employs approximately 1,800 people in the UK, and spends on average £1.6 billion each year, supporting over 1,000 British companies (80 per cent of which are SMEs), and 20,000 jobs.

2. Lockheed Martin provides a range of capabilities to the Royal Navy (RN). It:-

   a. Is the prime contractor for the F-35 Programme,[1] Crowsnest Programme, and various mission systems (including the Navigation Compass, Naval Radar, and Warship Electronic Chart Display and Information System programmes);

   b. Was the prime contractor for the Merlin Mk2 helicopter upgrades, and now manages two support contracts – Integrated Merlin Operational Support, and Merlin Training System;

   c. Is responsible for upgrading the sonar systems of, and providing the Towed Array Palliative and future Buoyant Wire Antenna system for, the Vanguard Class submarines;

   d. Provides the Tactical Tomahawk Weapons Control System for the Astute Class submarines; and

   e. Provides the Mk 41 Vertical Launch System for the Type 26 frigates.

3. For allied navies, Lockheed Martin designs, produces, and integrates surface combatant ships, combat mission systems, electronic warfare systems, long-range anti-ship missiles, missile defence radars, rotary platforms, autonomous platforms, and the only deployed Laser Directed Energy Weapon (LDEW) system.

4. Based on this experience, Lockheed Martin UK's (LMUK) submission focuses on future maritime operating concepts, resulting naval capability considerations, and the Committee's specific questions about F-35 and Crowsnest.

<u>Part 1</u>

Question 1

1. The U.S. Navy (USN) and U.S. Marine Corps (USMC) are developing new operational concepts – Distributed Maritime Operations (DMO), and Expeditionary Advanced Base Operations (EABO). These reflect the threat environment in which naval forces will operate, characterised by anti-access/area-denial (A2/AD) capabilities. The concepts also reflect the opportunities presented for naval forces by new technologies. They aim to achieve:-[2]

   a. A more distributed fleet architecture. Rather than concentrating on a limited number of large ships or grouping of vessels, manned and unmanned assets will be deployed over multiple locations and large distances, and networked to allow synchronised

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[1] It should be noted the F-35 Programme's procurement profile is managed through Air Command's Combat Air budget.
[2] See Congressional Research Services, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress'* RL32665, 24 July 2019.

operations. The aim is to enhance situational awareness, and the range of effects that can be employed. It will challenge the ability of adversaries to target assets; and

b. A *'presence on key maritime terrain (islands and chokepoints). By emplacing long range weapons systems within these bases, marines would create an anti-access envelope, within which enemy ships and aircraft would find it difficult and hopefully impossible to operate… Under such a construct, a naval force would be able to conduct operations while sheltering under a land-based anti-access umbrella'*.[3]

2. Underpinning capabilities for these concepts include distributed and long-rage sensors, distributed command and control, disaggregated and long-range effectors, and autonomous systems. As the RN considers its future capabilities, it will need to be cognisant of these concepts. It will also need to be cognisant of the capability choices of allies, to achieve interoperability and interchangeability. For example:-

   a. The Commander of U.S. Pacific Air Forces said in relation to the F-35: *'people often underestimate the strategic importance and operational benefits of allies operating the same system'*.[4] Strengthening global F-35 alliances is the most cost-effective way to pace the rapidly growing scale of adversaries, and operate in expansive regions such as the Indo-Pacific, and amplifies deterrence; and

   b. Naval partners in Europe and the Indo-Pacific are procuring common radars (e.g. SPY-7), combat mission systems (e.g. Aegis), and anti-ship missiles (e.g. the Long Range Anti-Ship Missile). The RN should consider how it gets involved in these programmes, including opportunities for collaborative capability development.

Question 2

<u>Maritime Aviation</u>

3. The RN has an enduring requirement for Airborne Early Warning (AEW) and Anti-Submarine Warfare (ASW) capabilities. These currently are provided by the Merlin Mk2 helicopter fleet (see paragraphs 21 to 24 on AEW). It is generally accepted that the fleet, which operates separate radars and mission systems for AEW and ASW, is not sufficient to sustain the demands of both missions. The MoD is exploring future capability options and fleet mixes, as part of its Future Maritime Aviation Force (FMAF).

4. LMUK recommends that:-

   a. Operational analysis be undertaken, in collaboration with industry, to identify the optimum balance between manned and unmanned aerial assets, other force assets (such as undersea vessels), and associated payload and sensor characteristics. As the UK transitions to new fleet mixes, it should consider how operating costs will directly correlate with the national or global fleet size, and ability to share non-recurring engineering costs with allies;

   b. The RN considers introducing a single radar and mission system onto the Mk2 helicopters, as part of a Life Extension Programme. This would allow all the helicopters to perform both AEW and ASW roles;

   c. The Mk2 be used as a low-risk testbed for unmanned and remotely operated capabilities; and

[3] See https://warontherocks.com/2019/07/the-dumbest-concept-ever-just-might-win-wars/.
[4] See https://www.airforcemag.com/wilsbach-to-allies-learn-from-usafs-mistakes-fly-your-f-35-like-an-f-35/.

d. Investment is made in the mission capabilities of the Mk 2 to develop an open architecture, and command and control network, that can incorporate autonomous technologies. This would de-risk and support transition to FMAF.

Underwater Battlespace

5. ASW and Underwater Battlespace (UWBS) capabilities are not limited to the Merlin Mk2; the UK has acquired the P-8 Maritime Patrol Aircraft, and Type 26 frigates. The benefits of this force composition should be maximised through integration of these platforms with other weapons and sensor capabilities, and new doctrine and operating concepts.

6. LMUK recommends that the RN further enhance its ASW/UWBS capability by:-

   a. Better exploiting existing systems, by undertaking enhanced Operational Analysis with Original Equipment Manufacturers (OEMs). The USN Undersea Warfighting Development Centre's relationship with industry is a good model, which the RN could adopt within its Maritime Warfare Centre;

   b. Using open/common architectures to allow rapid, and cost-effective, spiral development of capabilities, including through the insertion of Commercial Off The Shelf technology. The USN's Acoustics-Rapid COTS Insertion (A-RCI) is an example of this approach, which delivers acoustic superiority using existing sonar sensors. It has been used in the UK for systems on the Vanguard Class submarines. The concept is being considered for the Dreadnaught Programme;

   c. Implementing Multi-Static Operations, which use a variety of active and passive sonars, and enabling Multi-Domain Integration, using fused inputs from sensors in the maritime, space, and air domains. The integration of sensors from different domains will require relays, and standardised interfaces and data formats. These should be key considerations when making future investments across the Services;

   d. Investing in stealth technologies to support ASW/UWBS; and

   e. Developing novel approaches to achieve persistent and resilient surveillance, and deliver effects. These could include autonomous, meshed sensor and communication networks across domains; new undersea communications networks; autonomous data fusion; greater use of unmanned undersea vehicles with long endurance; new concepts of operation between unmanned and manned submarines, which could open new options for manned submarine design; Big Data tools; and non-acoustic detection, such as quantum magnetometry.

Integrated Air, Missile, and Space Defence

7. The threat from ballistic and other air breathing technologies is rapidly evolving:-

   'Potential adversaries are investing substantially in their missile capabilities. They are expanding their missile capabilities in three different directions simultaneously: increasing the capabilities of their existing missile systems; adding new and unprecedented types of missile capabilities to their arsenals; and integrating offensive missiles ever more thoroughly into their coercive threats, military exercises, and war planning.

   New ballistic missile systems feature multiple independently targetable re-entry vehicles (MIRV) and maneuverable re-entry vehicles (MaRV), along with decoys and jamming *devices. Russia and China are developing advanced cruise missiles and hypersonic missile capabilities that can travel at exceptional speeds with unpredictable flight paths...'.*[5]

8. The absence of a capability to effectively detect, and counter, these threats is a discernible gap in the RN's force protection and deterrent credibility. The RN should consider:-

    a. Investing in radar capabilities with sufficient range and discrimination to enable the simultaneous detection of ballistic and air breathing targets (both endo-atmospheric and exo-atmospheric). Five Eyes and other allies are focusing on solid state Active Electronically Scanned Array (AESA) sensors;

    b. Interoperability of the radars with allies, through a common combat system;

    c. Interoperability with strategic radars, such as the UK's planned Ballistic Missile Defence Ground Radar (and allied equivalents), and the potential for common training, logistics, and spares between maritime radars and the Ground Radar;

    d. Investing in effective interceptors and effectors, and making provision for ships to have common vertical launching systems (VLS) for them (see paragraphs 10 and 12); and

    e. Developing an architecture to share raw sensor data across all sensors and effectors, enabling any asset to engage any threat. The RN could learn lessons from the USN's Cooperative Engagement Capability (CEC), and Naval Integrated Fire Control-Counter Air (NIFC-A), initiatives.[6]

9. Finally, maritime radars can support wider missions, such as Space Domain Awareness, if they have sufficient sensitivity, range resolution, and discrimination capabilities.

<u>Strike and Launch Systems</u>

10. The RN has various anti-ship and land-attack missile systems, including the Harpoon (which has an out of service date of 2023), Sea Venom, and Tomahawk Land Attack Cruise Missile. Future strike capabilities, particularly to replace Harpoon, must establish a credible deterrent and project lethal force, rather than just enabling reactive defence. This means that (Figure 1):-

    a. Weapons systems should have increased range, survivability, probability of hit and kill, and, given the proliferation of denied communication environments, more autonomous attributes;

    b. The magazine capacity of ships will need to increase; and

    c. Layered defensive architectures may need to incorporate novel weapons, to counter the operational advantages offered to adversaries by high-speed weapons and swarming (see paragraphs 13 and 14).

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[5] U.S. Department of Defense, *2019 Missile Defense Review*, Office of the Secretary of Defense, pp. III-IV.
[6] See https://www.secnav.navy.mil/rda/Pages/Programs/CEC.aspx#:~:text=As%20a%20key%20pillar%20of,missiles%20in%20a%20joint%20environment..

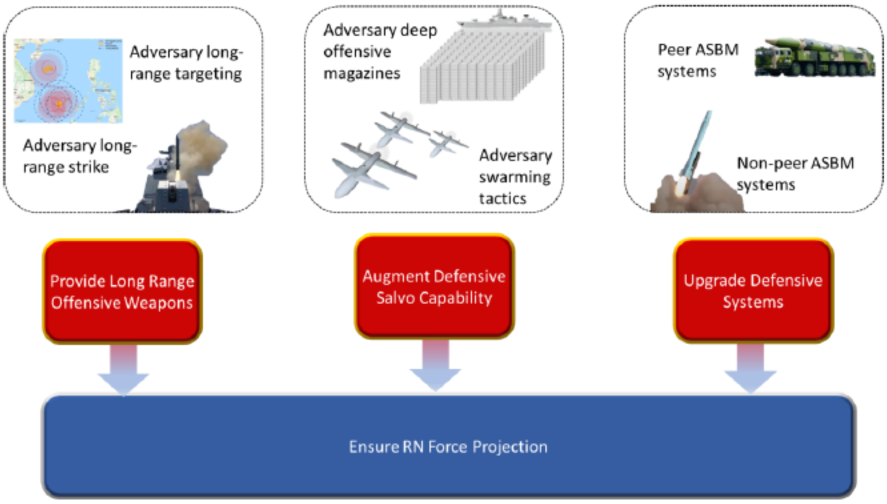

Figure 1: Threats and related capability requirements for anti-surface warfare

11. The UK's industrial base could face challenges in developing weapons systems with these characteristics.[7] The systems have high development costs, which could in turn impact stockpile numbers, and long development timescales. Moreover, the UK's focus on 'Commonality, Modularity, and Re-use' for weapons has constrained onshore solutions, by limiting concepts. Collaborating with the U.S. could enable reduced development costs, larger stockpiles, lower risk and earlier transition to new capabilities, better interoperability, and inclusion of UK companies in larger programmes of record. Assured Capability could be achieved through onshore Design Authority, by incorporating UK components and sub-systems, and through knowledge and technology transfer.

12. The RN has recognised the importance of a flexible VLS, to enable the effective deployment of weapons, including strike systems. Currently, it operates the Sylver VLS, but has invested in the Mk41 VLS for the Type 26. The Mk41 offers greater choice for the delivery of effectors. The absence of a VLS for the Type 45 Destroyer, despite provision being made in its design, and the limitation of Tomahawk to submarine launch, has confirmed the benefit of all RN vessels adopting the same multi-purpose VLS. Threat analysis indicates VLS should have greater capacity.

<u>Disruptive Weapons</u>

13. The MoD is undertaking a series of demonstrators to assess Directed Energy Weapons within a maritime context. Analysis undertaken by LMUK has demonstrated the operational benefits of incorporating a high-powered LDEW in a layered defensive architecture, as well as the significant cost reductions that would result compared to operating only a conventional close-in weapons system such as Phalanx.

14. Developing high-powered LDEW systems with a high quality beam would be costly, and, based on experience in other countries, take up to 20 years.[8] The UK could leverage U.S. development programmes, whilst meeting Assured Capability requirements and building onshore capability.

<u>Part 2</u>

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[7] This point is also relevant to Part 2, Question 6 of the Committee's inquiry.
[8] *Ibid.*

Question 1

F-35 Programme

15. The F-35B aircraft forms a core element of Carrier Enabled Power Projection (CEPP). Initial Operating Capability (IOC) Maritime for the UK's F-35B fleet was declared in December 2020, and Carrier Strike Group 21 (CSG21) deployed in May 2021. Autonomic Logistics Information System (ALIS) experts and Field Service Engineers from LMUK will be embarked on HMS Queen Elizabeth to support F-35 operations throughout the deployment. LMUK is also part of an industry team that provides 24/7 second line support from RAF Marham.

16. Unlike legacy aircraft used for carrier operations, the F-35's advanced suite of sensors and weapons allows multiple missions to be undertaken using a single platform. These include Defensive Counter Air, Suppression and Destruction of Enemy Air Defences, Strike, Close Air Support, Anti-Ship, and Intelligence, Surveillance and Reconnaissance. Additional capabilities will be inserted throughout the life of the aircraft. The F-35 has also been proven to enhance the operational effectiveness of other platforms, and can enable Multi-Domain Integration.

17. The MoD has an overall Programme of Record (POR) for 138 F-35 aircraft. The procurement of 48 F-35B aircraft within this POR is currently confirmed, of which 21 have been delivered to date. Once 48 aircraft are delivered, the MoD could routinely deploy 24 F-35B aircraft for CEPP, whilst continuing to provide a training squadron. However, this fleet size leaves little resilience, and would not allow the UK to meet the full capacity of a single carrier (36 jets) without impacting training throughput.

18. The delivery profile for the initial 48 aircraft has markedly slowed due to financial pressures, notwithstanding the recent increase in the defence budget. It is likely that this will delay the stand up of a second frontline squadron of F-35Bs by at least three years (to 2026).

19. Lockheed Martin assesses that 70 to 80 F-35B aircraft are required to deliver a credible and resilient CEPP capability, throughout the life of the Queen Elizabeth Class carriers (to 2068).[9] This has been confirmed in public statements by the MoD. It would allow 48 F-35B aircraft routinely to be available for CEPP,[10] providing greater resilience, and the ability to surge to 36 aircraft without any impact on training. 138 F-35s would be required to allow the UK to deliver carrier strike alongside other non-discretionary and contingent combat air tasks; the F-35 is capable of fulfilling all Typhoon missions.

20. Lockheed Martin recognises that the F-35 represents a substantial investment for the UK to recapitalise its Combat Air capability. It is committed to reducing acquisition, and sustainment, costs:-

    a. The F-35B Unit Recurring Flyaway (URF) cost has reduced by over 37 per cent, since the UK's first order in 2009 (from US$161 million to $101.3 million in 2020).[11]

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[9] Allocations could include: three aircraft for test and evaluation; 14 aircraft to each of three frontline squadrons (ideally each squadron would have 16 aircraft, in order to guarantee routine operations with 12 jets, allowing for maintenance and unavailability); 20 aircraft to the training squadron (without a larger operational conversation unit, the Lightning force will fail to deliver the required throughput of pilots and maintainers to satisfy three frontline squadrons); a minimum of three aircraft in a sustainment fleet (modifications and upgrade programme). The MoD would likely assume a baseline attrition rate of one aircraft every five years, which also needs to be taken into account as part of future orders.

[10] Brigaded as either three frontline squadrons of 16 aircraft, or four squadrons of 12 aircraft.

The URF is lower than targeted in Lockheed Martin's 'Blueprint for Affordability' initiative, which aimed to bring the URF down to $105 million by the 2020 production lot, and equal to or less than that of previous combat aircraft. URF reductions are also evident for the A and C variants. Future URF costs are subject to negotiation by the F-35 Joint Program Office (JPO). More reductions are anticipated; and

b. Lockheed Martin has invested $500 million to reduce its portion of the cost per flight hour (CPFH), which has reduced by 40 per cent since 2015. Continued investments are expected to reduce this CPFH element by another 40 per cent over the next five years. Lockheed Martin is working with the JPO to ensure it (and its customers, including the MoD) have a full understanding of the technical characteristics of the aircraft, so that other aspects of CPFH can be improved. This situation is not unique to the F-35. It applies to all Combat Air platforms. For example, in 2016, the Typhoon Total Availability eNterprise (TyTAN) arrangement was established between to reduce the costs of operating the Typhoon fleet. As F-35 aircraft fleets scale, further sustainment reductions are also expected. The U.S. Secretary of the Air Force nominee said: *'The key to keeping the costs down in an airfleet is getting the numbers up... There's a very strong correlation between the size of the fleet and the cost to sustain that fleet. So if there were one thing that I think would drive costs down, it's continuing to buy'*.[12]

Crowsnest

21. In 2017, Lockheed Martin was awarded the contract to deliver long-range air, maritime, and land tracking capabilities for early threat detection. As prime contractor, Lockheed Martin is responsible for the overall design and development of the Crowsnest system, incorporating a radar and mission system from Thales, and working with Leonardo Helicopters to design modifications for the Merlin airframes. 10 Crowsnest systems are being developed, and all 30 Merlin Mk2 helicopters will be equipped to receive them.

22. The National Audit Office (NAO) reported on the Crowsnest programme in June 2020:-

'[The MoD] expected to achieve initial Crowsnest operating capability in September 2021, some 18 months later than planned. As this is later than the December 2020 milestone for declaring initial operating capability for Carrier Strike, the Department is working to provide a credible baseline radar capability for the first deployment [in 2021]…'.[13]

23. The NAO noted that the delay was principally caused by Thales failing to meet its contractual commitments for developing equipment, and not providing sufficient or accurate information on the project's progress.[14]

24. As a result of the delay, a baseline requirement for a deployable capability in support of CSG21 was determined by the MoD, based on threat assessments. Three Crowsnest-

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[11] In addition:-

- The UK has had some aircraft modification costs. These are the costs for ensuring aircraft procured under early production Lots meet UK standards for IOC. Eleven of the 21 aircraft delivered to UK were fully compliant with IOC (Maritime) requirements. The remaining nine aircraft required a single modification to the F-35B landing gear, which extended their service life for operations on ski-jump carriers; and
- In-service aircraft will receive regular software updates to ensure they maintain operational advantage, through an Advanced Capability Insertion (ACI) Programme. The UK's cost share will be pro-rata, based upon the percentage of aircraft it purchases across the global POR.

[12] Testimony to United States Senate Committee on Armed Services, 25 May 2021.

[13] National Audit Office, *Carrier Strike – Preparing for* deployment, HC 374, Session 2019-2021, 26 June 2020, para 2.7.

[14] *Ibid.*, para. 2.4

configured Merlin Mk2 helicopters that meet this requirement have deployed in support of CSG21. They will receive regular software updates throughout the deployment, to further enhance their capability.

Question 8

25. Based on Lockheed Martin's experience in designing and delivering naval platforms and missions systems, it would highlight the following lessons:-

    a. The importance of using common architectures, and standards, for mission systems and weapon systems. This allows for the cost-effective and rapid development, and insertion, of additional applications to meet evolving threats. The Aegis Combat System, including its Common Source Library, is the pre-eminent example of a successful open and scalable architecture used across a variety of ship classes (and land-based systems) globally. To date, the RN's suppliers have tended to base their solutions on proprietary/closed architectures, making it difficult to integrate other capabilities. This also creates interoperability challenges for allies; and

    b. The need to incorporate sufficient space, and spare weight and power capacity, in the design process to allow the physical integration of additional, modular capabilities over time.

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